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JUVENILE BONEFISH (*ALBULA VULPES*) IN GREAT SOUTH BAY, NEW YORK

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ABSTRACT

During August and September (1962), 108 juvenile bonefish ranging from 33 to 81 millimeters in fork length were seined at Mercer's Island in Great South Bay (N. Y.). While they were present, the juveniles exhibited rapid growth equal to a modal increase of 25 millimeters with no overlapping sizes during the two months. It is assumed that these bonefish were present at this northerly extreme of their range through larval drift and inshore migration of metamorphosing leptocephali into an environment suitable for transformation.

In the course of gathering age-length data on young northern kingfish (*Menticirrhus saxatilis*) at Mercer's Island in Great South Bay along the south shore of Long Island (N. Y.) during the summer and early fall of 1962, more than 100 juvenile bonefish (*Albula vulpes*) were collected incidentally. The collection of so large a number of bonefish at the northern extremity of its range is unprecedented. Even more surprising was the occurrence of these fish in the post-leptocephalus or juvenile state of development (Figure 1), an age category which is sparsely recorded in the published literature.

Gill (1907), Hollister (1936), Fitch (1950), Rasquin (1955) and Alexander (1961) have all described, either in whole or in part, the unusual metamorphosis and growth of larval bonefish, but little or no mention has been made by these authors of the growth of the juveniles following metamorphosis. Indeed, even the inclusion of juvenile bonefish, i.e., those having adult form but a standard length of less than 150 millimeters, in various geographical studies of fishes has been rare. The collections made by Meek and Hildebrand (1923) on both coasts of Panama, by Beebe and Tee-Van (1928) at Haiti, and by Beebe and Hollister (1935) in the British West Indies included only leptocephaloid larvae and adults larger than 150 millimeters in length. Longley and Hildebrand (1941) reported collect-

ing "young" bonefish on two occasions at Tortugas, Florida, but they made no mention of either size or numbers caught. Erdman (1960) recorded the capture at Puerto Rico of "2 small bonefish with adult form and coloring 2⅛" standard length", and Fitch (1950) described a collection of larval *Albula* made at San Felipe Bay, Lower California, which included a transformed specimen that he called a

Figure 1. Juvenile bonefish seined at Mercer's Island in 1962.
Top —35 millimeters fork length, taken August 16
Center —55 millimeters fork length, taken August 21
Bottom—78 millimeters fork length, taken September 18

"young fish stage". This bonefish was reported to be 36 millimeters in standard length and the juvenile pigmentation was evident in the accompanying photograph. A 51.2-millimeter (standard length) juvenile collected at Miami, Florida, was illustrated and described by Alexander (1961) and was the only specimen of this stage of development included in her study. These appear to be the only positive records, in the available literature, of juvenile bonefish collected in field studies.

METHODS

Bonefish collections were made with a 6 x 300-foot beach seine comprised of 1½-inch stretch nylon mesh in the outer section of the wings, ¼-inch knotless nylon mesh in the inner section of the wings,

and 1/8-inch knotless nylon mesh in the "pocket" or cod end. Seining was done at Mercer's Island only on those days when weather conditions precluded other scheduled field operations. The net was set two to four times in approximately 1 to 6 feet of water at various locations around the island perimeter on each seining day.

After each haul, all fish captured were identified and enumerated by species. When a species was present in abundance, only an estimate of the total number was made. Identification and enumeration of invertebrates and algae were also made when possible. Water temperature and salinity were recorded daily.

All bonefish were removed from the catch and placed in a 10 per cent formaldehyde solution for subsequent examination. At the laboratory these fish were measured to fork length in millimeters and monthly length-frequency distributions were made. Scales were removed from a few of the larger individuals and examined for age determination.

RESULTS

During seining operations on 10 days from late July to mid-October, 108 bonefish were collected on six different occasions during August and September. The data are recorded in Table 1. Using

TABLE 1. DATA PERTAINING TO BONEFISH COLLECTED AT MERCER'S ISLAND IN GREAT SOUTH BAY DURING 1962

Date	Number collected	Size range (fork length in millimeters)	Water temperature* (° F.)	Water salinity (‰)
July 24	0	..	74	25.0
August 13	0	..	74	23.6
August 14	1	45	67	24.8
August 16	75	33–52	74	24.8
August 21	14	41–54	..	..
September 5	2	60–67	68	25.0
September 17	0	..	69	25.2
September 18	1	81	67	25.4
September 24	15	61–76	58	26.0
October 16	0	..	59	25.0

* 2 feet below surface.

a 5-millimeter class interval, length frequency histograms (Figure 2) indicate a modal fork length of 45-49 millimeters in August with a range of 30-59 millimeters and a modal fork length of 70-74 millimeters in September with a range of 60-84 millimeters. Microscopic examination of scales indicated that no annuli were present and, in fact, suggested that all bonefish collected were of the 0 age group.

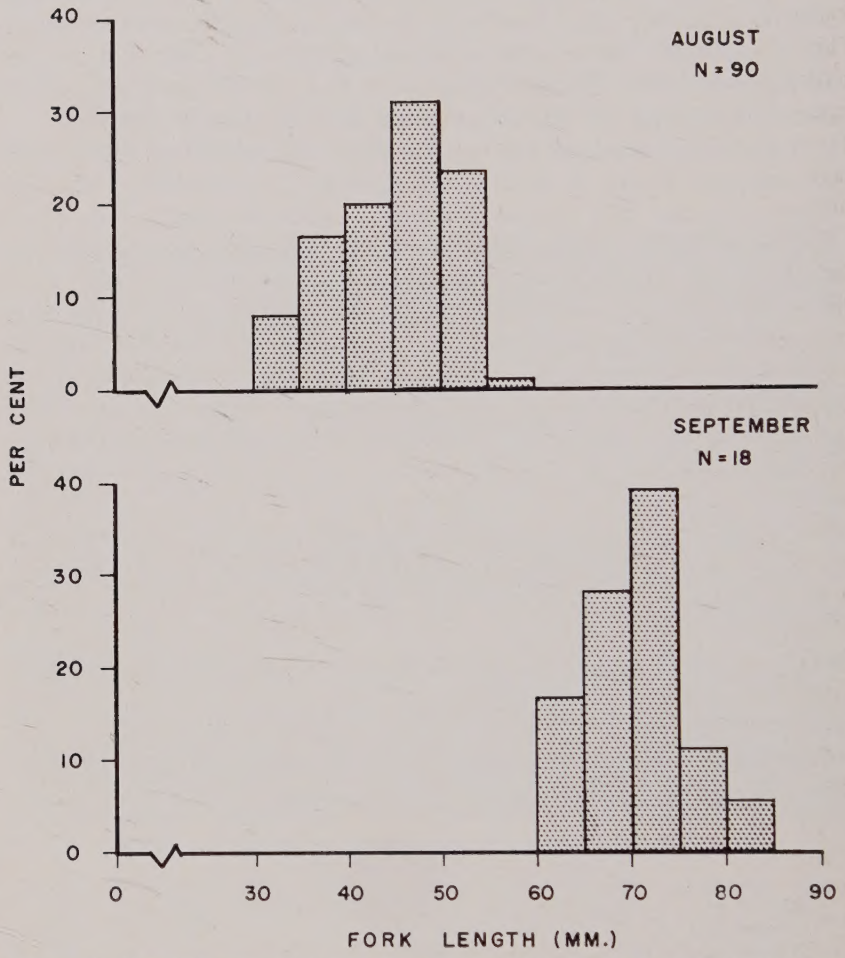

Figure 2. Length-frequency distributions for bonefish captured at Mercer's Island during August and September, 1962.

DISCUSSION

The capture of over 100 bonefish in New York waters is unique. DeKay (1842) included the species as "extra-limital" in his "Zoology of New York", but Jordan and Evermann (1896) stated that *Albula vulpes* ranges northward to Long Island. Actually, on the Atlantic Coast there are records from as far north as Cape Cod, Massachusetts (Sumner, Osburn and Cole, 1913), but they are not recent. Nichols and Breder (1926) considered the occurrence of this species at New York to be "accidental, October", and, coincidentally, Breder and Nigrelli (1934) reported a 2-foot specimen from Long Island Sound

in October 1933. Neither Greeley (1939) nor Gordon (1949, 1951) recorded the presence of bonefish in their respective field collections. The most recently reported occurrence of a bonefish (until the present instance) north of the South Atlantic States appeared to be Massman's report (1957) of a specimen caught in a pound net at Chesapeake Bay in March 1948. Staff biologists at the Bureau of Marine Fisheries have never seen or collected a bonefish from Long Island waters in more than 10 years of field studies.

The presence of adult bonefish in the vicinity of Long Island during the summer of 1962 is open to conjecture, but the pelagic nature of the leptocephali and their involuntary dispersal by ocean currents may offer a plausible explanation. According to Briggs (1960) *Albula* is one of only 14 species of fish of littoral habitat that have succeeded in establishing worldwide (circumtropical) distribution—in this case probably through larval drift. Alexander (1961) stated that bonefish larvae were taken by plankton nets offshore where bottom depths may reach 4,000 meters (although rather close to land areas) but metamorphosing stages were captured by dipnets in shallow bay areas and off piers. She assumed that spawning takes place "either offshore or in areas where currents would take the eggs offshore". Although *Albula* may spawn the year around in the West Indies (Alexander, 1961), and Erdman (1960) caught leptochephalus larvae at Puerto Rico every month in the year except July, the latter investigator found ripe bonefish only during the months of November through January. Erdman estimated a pelagic leptochephalus stage of 5 to 6 months. This could provide ample time for larvae from the West Indies, Florida or Bermuda to arrive off Long Island by late July or early August. In an aquarium tank, Hollister (1936) observed the transformation of a bonefish leptochephalus from a 55-millimeter larvae to a 20-millimeter juvenile in 10 days (August 14 to 24) at Bermuda, while Rasquin (1955) recorded shrinkage from large leptocephalus to young adult to take approximately 12 days depending on water temperature (average 22.8° C.). At Mercer's Island the water temperature was 74° F. (23.3° C.) on July 24, three weeks before the capture of the first juvenile bonefish and temperatures remained that high until August 13. The smallest bonefish were 33 to 55 millimeters in fork length on August 16 (63 of 75 specimens were less than 50 millimeters) which would imply that they had only recently metamorphosed. Although collections were made at Mercer's Island on July 24, well prior to the first day (August 14) that a bonefish was seined, transparent leptocephali might easily have been overlooked among some 4,000 silversides and anchovies. At tropical stations most bonefish leptocephali in shallow water areas are collected at night by dipnet. The location of Mercer's Island, near channels that lead

to the open ocean, makes it feasible for the inshore migration of bonefish leptocephali and subsequent metamorphosis to have occurred in this presumably favorable environment.

Salinities encountered at Mercer's Island (Table 1) were within the range of station surface salinities (25.5 to 36.89‰) reported by Alexander (1961) for locations at which bonefish larvae were collected, and temperatures during July and August were near or above 20° C. (68° F.). Alexander has shown that the distribution of bonefish leptocephali is restricted by the 20° C. isotherm and that temperature is the most likely limiting factor (hydrographically). It may be noted, however, that the juveniles of this species are able to survive more severe temperatures since 15 specimens were captured on September 24 when the surface water temperature had dropped to 58° F. (14.4° C.).

Assuming all the juvenile bonefish captured at Mercer's Island during August and September to have been of the same population, the length-frequency histograms plotted in Figure 2 indicate considerable growth during this relatively short period of time. Indeed, the difference between the monthly modal lengths was 25 millimeters, and there was no size overlap, i.e., all bonefish captured in September were larger than all those captured in August. Also, based on the absence of very small juveniles (30–60 millimeters) in the September collection, it would appear that few, if any, metamorphosing larvae remained in the vicinity of Mercer's Island at that time. This suggests that the metamorphosis of these fish probably had been completed by the end of August in Great South Bay and resulted in the termination of recruitment into the September catch.

ECOLOGICAL NOTES ON THE COLLECTING SITE

Mercer's Island, which lies in the southeast quadrant of Great South Bay (see U.S.C.&G.S. Chart 578) one nautical mile north of Point O' Woods on Fire Island, is a man-made sand island created in 1958 by spoil deposition from a nearby channel dredging operation. Originally the island was reported to be about 7 acres in size, but wind and water erosion have reduced it to not more than 4 or 5 acres of sparsely vegetated sand and shell. Although the island is near a boat channel having a mean average depth of 12 feet at low tide, it is entirely surrounded by shoals not more than 2 to 3 feet deep at mean low tide and dropping off to 5 or 6 feet at the southern extremity. The littoral area is composed of hard sand and shell and is almost devoid of vegetation. The adjacent channel connects directly with channels leading to Fire Island Inlet and the Atlantic Ocean (about 9 miles distant from the island). Because of its location Mercer's

Island is subject to considerable tidal action and the surrounding water is rather saline.

SALINITY AND TEMPERATURE

During the collecting period (Table 1) salinities were rather constant from a low of 23.6‰ at ebb tide on August 13 to a high of 26‰ at flood tide on September 24. Water temperatures (at 2 feet below surface) did not rise above 74° F. during the period of observation, and they reached a low of 58° F. on September 24.

VEGETATION

The waters about Mercer's Island were almost devoid of fixed vegetation, although the great numbers of large shells (*Mercenaria, Crassostrea* and *Spisula*) would appear to have offered a good subtrate for many algal forms. There was no eel grass (*Zostera marina*) growing, although drifting uprooted plants and decaying mats of leaves were noted occasionally. Of the green algae, three species of *Enteromorpha* (*E. intestinalis, E. compressa* and *E. linza*) were recorded growing on shells near the shore line. The only other attached form

TABLE 2. ALGAE COLLECTED AT MERCER'S ISLAND IN GREAT SOUTH BAY, JULY-OCTOBER, 1962

Species	Condition	Relative abundance
Chlorophyceae		
Enteromorpha clathrata	floating	infrequent
Enteromorpha compressa	growing attached	one specimen
Enteromorpha intestinalis	growing attached	fairly common
Enteromorpha linza	growing attached	fairly common
Ulva lactuca	floating free	uncommon
Phaeophyceae		
Sphacelaria radicans	floating*	fairly common
Sphaerotrichia divaricata	floating	rare
Rhodophyceae		
Agardhiella tenera	floating	infrequent
Gracilaria foliifera	floating	rare
Champia parvula	floating*	common
Callithamnion roseum	floating	common
Callithamnion byssoides	floating	infrequent
Griffithsia globulifera	floating	one specimen
Griffithsia tenuis	floating masses	common
Ceramium fastigiatum	floating masses	common
Ceramium rubrum	floating	fairly common
Dasya pedicellata	floating	infrequent
Polysiphonia harveyi	floating	one specimen
Polysiphonia flexicaulus	growing attached	uncommon

* Frequently on *Zostera*.

was the red alga *Polysiphonia flexicaulus* and only a few small specimens of this were collected. At times, floating algae were fairly common but they obviously were drift material from other locations in Great South Bay. Most of these free-floating forms were red algae sometimes mixed with one or more species of brown algae and small pieces of *Ulva lactuca*. A great deal of this unattached algal accumulation was in various stages of disintegration but many species were identifiable. On any one day a single species might predominate in the flotsam, but *Ceramium, Champia, Griffithsia* and *Callithamnion* were most representative. The species of algae collected at Mercer's Island and their relative abundance are recorded in Table 2.

Invertebrates

A few invertebrates are generally collected by the shore seining method, and in areas of abundance some of the larger and more active forms are regularly recorded. About Mercer's Island few invertebrates

Table 3. Invertebrates Collected at Mercer's Island in Great South Bay, July-October, 1962

Species	Number of occurrences	Daily maximum
Porifera		
Cliona celata	1	3
Microciona prolifera	3	4
Coelenterata		
Chrysaora quinquecirrha	3	abundant*
Unidentified medusae	1	3
Ctenophora		
Mnemiopsis leidyi	6	abundant§
Arthropoda		
Crustacea		
Crangon septemspinosa	4	4
Palaemonetes vulgaris	2	3
Pagurus longicarpus	2	3
Ovalipes ocellatus	4	6
Callinectes sapidus	4	6
Neopanope texana sayi	4	3
Unidentified isopods	3	4
Mollusca		
Pelecypoda		
Solemya velum	2	3
Cephalopoda		
Loligo pealii	1	1

* On August 14.
§ On September 5, 17, 18 and 24.

were captured and only two floating types, the scyphomedusan *Chrysaora* (*Dactylometra*) *quinquecirrha* and the ctenophore *Mnemiopsis leidyi*, were recorded as abundant on occasion. No attempt was made to dredge for bottom fauna, but the stomach contents of two juvenile northern kingfish contained fresh examples of the awning clam (*Solemya velum*) which is known to be abundant in the bays of the south shore at depths of about 0.6 to 3.7 meters. Townes (1939) reported as many as 100 per square meter. The accompanying list of invertebrates (Table 3) reveals the small numbers and limited variety of species encountered during the collecting period.

FISHES

Only 32 species of fish, including bonefish, were recorded from Mercer's Island. The seasonal peak was the 25 species collected on September 5. The average number recorded was 14.3 with a low of only nine species on October 16. This relative paucity of species and numbers of fish is shown in Table 4. It may be noted that only one species (*Menidia menidia*) occurred on every collecting date. The other species recorded on more than half of the seining days were *Albula vulpes, Synodus foetens, Strongylura marina, Syngnathus fuscus, Pomatomus saltatrix, Menticirrhus saxatilis, Stenotomus chrysops, Scophthalmus aquosus, Pseudopleuronectes americanus* and *Sphaeroides maculatus*. These 11 species, then, predominated in this environment. However, if total numbers of specimens collected are evaluated the species composition is different. The 10 most numerous species listed in descending order were *Menidia menidia* (19,250), *Anchoa mitchilli* (2,025), *Sphaeroides maculatus* (316), *Stenotomus chrysops* (236), *Menticirrhus saxatilis* (197), *Pomatomus saltatrix* (154), *Strongylura marina* (143), *Albula vulpes* (108), *Bairdiella chrysura* (95) and *Tautoga onitis* (72). Only the Atlantic silversides occurred in great numbers with estimates as high as several thousand adults and juveniles per day. On October 16 it was estimated that 10,000+ *Menidia* were seined while only about 20 specimens of other species were taken. The number of bay anchovies is deceiving. Although this species ranked second in over-all abundance, 2,000 were seined on one day and during the remainder of the time it was of minor importance. It is ordinarily encountered at greater depths than are provided by the shallows about Mercer's Island.

Of all the species taken at Mercer's Island, six would not be considered to occur annually. These are: *Albula vulpes* (108 juveniles); *Synodus foetens* (27 adults and juveniles), usually rare; *Astroscopus guttatus* (five juveniles), an accidental, particularly as young; *Hyporhamphus unifasciatus* (two juveniles), young not frequently reported at Great South Bay; *Fistularia tabacaria* (one juvenile), a rare sum-

TABLE 4. FISHES RECORDED FROM MERCER'S ISLAND IN GREAT SOUTH BAY, JULY 24-OCTOBER 16, 1962

Species*	Number of occurrences	Number of specimens	Age§
Albulidae			
Bonefish (*Albula vulpes*)	6	108	J
Engraulidae			
Bay anchovy (*Anchoa mitchilli*)	5	2,025	A, J
Synodontidae			
Inshore lizardfish (*Synodus foetens*)	7	27	A, J
Anguillidae			
Americal eel (*Anguilla rostrata*)	1	1	A
Belonidae			
Atlantic needlefish (*Strongylura marina*)	8	143	A, J
Hemiramphidae			
Halfbeak (*Hyporhamphus unifasciatus*)	2	2	J
Gasterosteidae			
Fourspine stickleback (*Apeltes quadracus*)	2	14	A
Fistulariidae			
Cornetfish (*Fistularia tabacaria*)	1	1	J
Syngnathidae			
Northern pipefish (*Syngnathus fuscus*)	9	42	A
Serranidae			
Black sea bass (*Centropristes striatus*)	1	2	J
Striped bass (*Roccus saxatilis*)	1	6	A
Pomatomidae			
Bluefish (*Pomatomus saltatrix*)	9	154	A, J
Carangidae			
Crevalle jack (*Caranx hippos*)	1	1	J
Sciaenidae			
Silver perch (*Bairdiella chrysura*)	3	95	A, J
Spot (*Leiostomus xanthurus*)	1	30	J
Northern kingfish (*Menticirrhus saxatilis*)	8	197	J
Sparidae			
Scup (*Stenotomus chrysops*)	6	236	J
Labridae			
Tautog (*Tautoga onitis*)	5	72	J
Cunner (*Tautogolabrus adspersus*)	5	19	J
Triglidae			
Striped searobin (*Prionotus evolans*)	4	12	J
Uranoscopidae			
Northern stargazer (*Astroscopus guttatus*)	5	5	J
Stromateidae			
Butterfish (*Poronotus triacanthus*)	2	5	J

TABLE 4. (*continued*)

Species*	Number of occurrences	Number of specimens	Age§
Mugilidae			
Striped mullet (*Mugil cephalus*)	2	10	J
White mullet (*Mugil curema*)	3	10	J
Atherinidae			
Atlantic silverside (*Menidia menidia*)	10	19,250	A, J
Bothidae			
Summer flounder (*Paralichthys dentatus*)	3	3	A, J
Windowpane (*Scophthalmus aquosus*)	6	12	J
Pleuronectidae			
Winter flounder (*Pseudopleuronectes americanus*)	7	60	A, J
Balistidae			
Orange filefish (*Alutera schoepfi*)	1	1	J
Planehead filefish (*Monacanthus hispidus*)	1	1	J
Tetraodontidae			
Northern puffer (*Sphaeroides maculatus*)	8	316	A, J
Batrachoididae			
Oyster toadfish (*Opsanus tau*)	2	2	J

* Common and scientific names after the American Fisheries Society (1960).
§ A = adult; J = juvenile.

mer visitant; and *Monacanthus hispidus* (one juvenile), absent during some summers.

Although 13 of the 23 species collected at Mercer's Island were represented by one or more adult specimens, young fish were much more characteristic of the area and many common species were represented only by juveniles. Even the adults of the piscivorous predators were scarce. For example, of 154 *Pomatomus saltatrix*, only one adult (approximately 3 pounds) was captured.

ADDENDUM

In addition to the record of Breder and Nigrelli (1934), Roy Latham (personal communication, 1964) reported two examples of bonefish from Orient, Long Island. One specimen, 21 inches long, was taken on October 1, 1939 and a second of 14 inches on June 17, 1940.

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PRODUCTIVITY AND GROWTH OF WHITE-TAILED DEER FROM THE ADIRONDACK REGION OF NEW YORK[1]

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ABSTRACT

To test the possibility that inherent characteristics are responsible for the low weights and reproductive rates of deer in the central Adirondacks, typical fawns (eight male and eight female) were transferred from an area where substantial winter starvation was chronic to corrals on an area in the southern part of the State having a less severe climate and an adequate food supply. During five winters the average population was equivalent to 36 to 38 deer per square mile in one corral and 62 to 64 deer per square mile in the other. At these densities the available food supply was fully utilized. The reproductive rates of the transferred stock, as adults, were equal to the best in New York. Their progeny averaged significantly heavier than deer from the central Adirondacks at comparable ages. The study demonstrated that deer from even the poorest range in the Adirondacks are not inherently different from deer elsewhere in the State. It seems clear that adequacy of nutrition is the primary factor responsible for differences that occur.

The vicinity of "The Plains" along the South Branch of the Moose River in Hamilton County has been a deer wintering area since long before 1890 (Smith and Severinghaus, 1954). In 1889, Harry Spinning, during what was probably no more than a 2-day trip, found 13 dead deer in the Little Plains country that had died of starvation (Boardman, 1904). Wellington Kenwell estimated that 250 deer died from starvation, disease or some unknown cause in The Plains area in 1893 (New York Fisheries, Game and Forest Commission, 1896, p. 229). By about 1900 white cedar, yew and witchhopple, which once occurred in great quantities, were virtually gone (Severinghaus and Brown, 1956); hemlock had also become scarce. Since then, starvation losses among deer wintering in this area have occurred almost annually.

During the 1940's between 1,000 and 2,000 deer wintered in this area of 14 to 15 square miles. The differences in population were largely caused by variations in the severity of losses during previous winters and the degree of concentration of deer from the surrounding area during each winter. For the winter of 1946–47 losses averaged about 10 deer per square mile of winter range, and in 1947–48 they

[1] A contribution of Federal Aid in Fish and Wildlife Restoration Project W-89-R. The authors are indebted to other game research and management personnel of the Department who helped make the deer drives that were necessary to count and collect the deer.

averaged about 20 per square mile. It had been evident since the early part of the decade that only a small supply of the browse species of good or better nutritional value existed on this winter range.

Some residents of this and other parts of the central Adirondacks had contended for many years that, as a result of the chronic starvation and other factors, a distinct strain of deer had developed. They contended that these deer had a low reproductive rate, were light in weight and developed small antlers and that mortality was greater among male fawns than female fawns prior to their first winter. These beliefs were used as arguments against "doe seasons". Data gathered during investigations by Department personnel also revealed low rates of reproduction and growth and poor antler development among deer in the central Adirondacks. But inadequate nutrition, rather than a different strain of deer, was considered to be the cause.

It seemed feasible to test the latter hypothesis by transferring fawns from an area in the Adirondacks where substantial winter starvation was chronic to an area in the southern part of the State having a less severe climate and an adequate food supply. Deer in The Plains area perhaps best represented the Adirondack conditions involved. The Partridge Run Game Management Area in Albany County afforded a suitable site to which to transfer fawns for study. There, they could be held in corrals that would make it possible to obtain the data desired. Winter is the critical period for deer in both localities.

Accordingly an experiment of this sort was undertaken in 1949. The major objectives were to determine the productivity of the transferred deer as well as the survival and growth of their progeny and whether either sex tended to predominate among the progeny. These would be considered in relation to the density of deer in the experimental area in winter. It was recognized that there would be too few deer to study antler development and that the corrals to be used would be too small to hold the progeny for more than one winter.

PROCEDURE

One corral, of 85.7 acres (0.134 square mile), had been constructed in 1941, and deer had been held in it from January 1942 until March 1946. During this period, the winter browse supply was seriously depleted and all deer were removed (Severinghaus, 1951). After that there were no deer in this corral until it was used for the present study. In the interim the open lands became more overgrown and a good browse supply developed. A second corral, of 56.8 acres (0.089 square mile), was constructed adjacent to the old one during the summer of 1949. It had an abundant supply of browse. Table 1 gives the cover-type composition of both corrals.

TABLE 1. COVER-TYPE COMPOSITION OF DEER CORRALS ON PARTRIDGE RUN GAME MANAGEMENT AREA

Cover type		Acres	
		Old corral*	New corral
Open	— grasses, with some trees and shrubs	24.35	3.02
Overgrown	— deciduous trees and shrubs	..	8.99
	conifers and shrubs	20.30	..
Woods	— immature hardwoods	15.85	11.04
	immature mixed woods	11.50	17.15
	mature mixed woods	5.75	..
	mature conifers	5.42	0.63
Reforestation	- spruce	2.50	..
	red pine and spruce	..	15.97
Total		85.67	56.80

* After Severinghaus (1951); at the time of the present study the areas occupied by the several cover types were essentially the same.

In the winter of 1949–50, efforts to trap deer in The Plains area were undertaken. But the weather was so warm that deer did not concentrate and could not be trapped. Mild weather during the winter of 1950–51 again made it impossible to obtain the deer necessary to start the experiment. During the winter of 1951–52, 76 adult deer (22 males and 54 females), six male fawns and two female fawns were caught in 43 days using eight and sometimes nine traps. However, two female fawns were not enough for the experiment. The winter of 1952–53 was also mild and deer were too difficult to catch to obtain the desired number of fawns. During the winter of 1953–54, 14 or 15 traps were operated continuously starting in mid-January. Over a period of 40 days, 35 adults (10 males and 25 females), 12 fawns (eight males and four females) and three other deer were caught. The two corrals were each stocked during February 1954 with two male and two female fawns.

It was found that the social and dominance habits of deer made it very difficult to catch fawns. Adults of both sexes would eat the food along the bait line and drive off the fawns. As a consequence, the adults were caught first and had to be moved more than 5 miles away from the baited traps before fawns could be taken.

Each winter following the stocking, three to six deer drives were made in each corral to determine the population and remove by shooting the fawns produced the previous spring. It was intended to leave the original deer in the corrals. The sex, age, weight and

reproductive condition of each deer removed were recorded. During these drives, usually in late January or February, the crews looked for evidence of deer that might have died during the fall or early winter. In the spring of each season, most of each corral was searched again for signs of dead deer.

The condition of the browse in each corral was observed periodically each winter. Visual appraisals for evidence of overbrowsing were made. One objective of the experiment was to limit the winter use at a level where deterioration of the supply would not occur. In the old corral particular attention was given to the degree of browsing on red maple and sugar maple among the better quality hardwood species and on white pine among the lower quality species. Hemlock was relatively scarce in this corral. In the new corral the degree of browsing on hemlock was used as a primary index.

The density of deer in the corrals each winter was considered to be the average number of deer per day per square mile. October 15 was used as the beginning of the winter period because deer begin feeding largely on browse about that time. The end of the period, i.e., when most of the snow had gone and deer could again forage on ground vegetation, varied from year to year as follows: April 7, 1954; April 12, 1955; May 2, 1956; April 11, 1957; April 24, 1958; and April 18, 1959. For each corral, the sum of the figures for the time the respective deer were actually present during the winter period constituted the total number of deer-days. These totals could not be finally determined until all the deer had been removed from a corral because some individuals avoided the observers during the annual winter censuses and, as a result, lived in the corrals longer than was planned.

Dividing such totals by the corresponding length in days of the winter period would give deer-per-day values that would represent conditions in the corrals but that could not be compared directly with data from deer wintering grounds in wild areas. This arises from the fact that, because they were under fence, whatever browsing the deer in the corrals did had to be within the corrals. On the other hand, deer in the wild, especially at the beginning of the winter before the snow gets deep, work in and out of the actual wintering grounds so that only part of their browsing is done there. The resultant less concentrated browsing on the wintering grounds would be equivalent to fewer deer-days than the calendar days of the winter period.

In an effort to take this difference into consideration, arbitrary values for the length of the winter period were used as the factor by which the total numbers of deer-days were divided. Two such values were used, namely, one of 100 days representing a mild winter, and one of 131 days representing a severe winter. Both were based on

Adirondack conditions and correspond to seasons approximating June ary 1 to April 9 and December 1 to April 9, respectively. Dividing the total number of deer-days by this factor and then by the number of square miles in the corral involved gave the density.

The age of each deer removed from the corrals was determined from the condition of its teeth as described by Severinghaus (1949), and their dates of birth were approximated. Critical examination of the teeth made it possible to estimate the age with sufficient accuracy to determine whether single, twin or triplet fawns were involved. In Tables 2 and 3 sex is indicated for the fawns listed under each female. It was, of course, not possible to know which female produced which fawns so this was done by assignment. In one instance, involving triplets, the female was killed the following winter and the corpora albicans were still conspicuous, thus confirming the interpretation.

FINDINGS

Productivity, survival, weight and sex of the experimental deer are discussed in relation to the density of the population in winter and the effect of deer use on the browse supply in the corrals.

Productivity and Survival

The productivity and survival record for deer in the old corral is summarized in Table 2, together with the sex of the fawns born there and other data pertaining to reproduction. Two male and two female fawns were placed in this corral in February 1954. The females had not been bred as evidenced by the fact that no fawns were born that spring.

On January 30, 1956 two female fawns were shot. Both were the same age and were judged to have been born about May 7, 1955. No other young deer were seen. However, a yearling female and yearling male were shot on January 26 and February 1, 1957, respectively, that had been born about August 1, 1955. Thus both of the original does had had twins in that year.

In 1957, too, a male fawn was shot on January 26 and a female fawn on January 27 that had been born about June 10 and May 10, 1956, respectively. Also, by mistake, the one remaining original male was shot on February 1 (the other had been transferred to the new corral on February 8, 1956) and the two original females were shot, one on January 27 and the other on February 1. It was believed that this eliminated all deer from the corral, and snow conditions did not occur that would permit tracking to prove otherwise. But on November 12 two yearling deer (both females) were killed in the corral. They must have been born in 1956. Moreover, one of the

original does had had three corpora albicans when she was killed. Thus it was proven that one doe had a single fawn and the other had triplets in 1956.

With respect to 1957, autopsy of the two original does revealed that each had twin female embryos.

On November 13, 1957 an original male was transferred from

Table 2. Productivity and Survival Record for Deer in the Old Corral

Female	Age of female			
	1 year	2 years	3 years	4 years
		Progeny*		
Doe A	0	2 F (1, 2)	1 F (4)	2 F §
Doe B	0	1 M, 1 F (3)	1 M, 2 F (5, 6)	2 F §
Fawn 1	0	xxx	xxx	xxx
Fawn 2	0	xxx	xxx	xxx
Fawn 3	0	1 M §	xxx	xxx
Fawn 4	1 †	xxx	xxx	xxx
Fawn 5	0	1 F (7)	1 M, 1 F (10)	‡
Fawn 6	0	2 F (8, 9)	2 F (11, 12)	1 †
Fawn 7	..•	xxx	xxx	xxx
Fawn 8	0	2 †	xxx	xxx
Fawn 9	0	1 †	xxx	xxx
Fawn 10	0	xxx	xxx	xxx
Fawn 11	0	xxx	xxx	xxx
Fawn 12	0	xxx	xxx	xxx
		Productivity of females		
Number	11 °	7	4	3
Progeny	1	11	8	5
Average	0.9	1.6	2.0	1.7
		Sex of progeny		
Male	0	2	2	0
Female	0	6	6	4
Unknown	1	3	0	1

* Progeny is considered to include actual embryos observed and those evidenced by the presence of corpora lutea when ovaries were examined. For the fawns, lack of progeny is based on absence of corpora lutea or corpora albicans. Numerals in parentheses after female fawns produced in the various years show origin of these fawns as subsequently listed in table. All fawns born survived at least 8 months. X's mean deer had been removed from corral.

§ Embryo.

† Corpus luteum.

‡ Doe had not ovulated when removed during breeding season.

° Does not include original does.

• No records.

the new corral. About June 1, 1958 the two does then in the old corral gave birth to three fawns, all females. They were not removed until August 25 and November 12, 1959 and February 19, 1960.

About June 1, 1959 the same does gave birth to four fawns, a male and three females (presumably two sets of twins). All deer were removed from this corral by February 23, 1960.

In all there were 12 female fawns produced in the old corral. During their first year, 10 of these did not become pregnant, one bred successfully (based on the presence of a corpus luteum[2]), and no records were made on the other. Among the adult does, including fawns born in the corral that survived beyond their first year, there

Table 3. Productivity and Survival Record for Deer in the New Corral

Female	Age of female					
	1 year	2 years	3 years	4 years	5 years	6 years
			Progeny*			
Doe A	0	2 M	1 M, 1 F (2)	2 M	2 M	2 M §
Doe B	0	1 F (1)	1 M, 1 F (3)	2 M	1 M	1 M, 1 F
Fawn 1	0	XXX	XXX	XXX	XXX	XXX
Fawn 2	0	XXX	XXX	XXX	XXX	XXX
Fawn 3	0	XXX	XXX	XXX	XXX	XXX
			Productivity of females			
Number	3 †	2	2	2	2	2
Progeny	0	3	4	4	3	4
Average	0	1.5	2.0	2.0	1.5	2.0
			Sex of progeny			
Male	0	2	2	4	3	3
Female	0	1	2	0	0	1

* Progeny is considered to include actual embryos observed. For the fawns, lack of progeny is based on absence of corpora lutea. Numerals in parentheses after female fawns produced in the various years show origin of these fawns as subsequently listed in table. All fawns born survived at least 8 months. X's mean deer had been removed from corral.

§ Embryo.

† Does not include original does.

[2] A corpus lutem is the yellow body that develops at the site of each shed egg in an ovary after pregnancy occurs. Its presence, therefore, is proof of pregnancy. A corpus albicans is the white, fibrous scar produced by the degeneration of a corpus luteum, and it persists beyond the term of the corresponding embryo.

were 14 pregnancies. These resulted in 24 fawns, embryos or corpora lutea, an average of 1.7 per doe. Eight pregnancies produced 15 fawns that survived, an average of 1.9; and six produced nine embryos or corpora lutea for an average possible productivity of 1.5 per doe. Of the fawns and the embryos that could be sexed, four were males and 16 were females.

The record for deer in the new corral is summarized in Table 3. This also was stocked in February 1954 with two male and two female fawns. The females had not been bred.

In 1955 two male fawns were born about June 1 and a female about June 10. The female and one male were shot on January 18, 1956, but the other male avoided detection until he was shot on January 29, 1959.

In 1956 two pairs (a male and female each) were born, one about May 25 and the other about June 25. These were shot on January 26, 1957.

In 1957 two sets of twins (all males) were born, one about May 25 and the other about June 25. The former were shot on October 23 and one of the others was shot on November 13 of the same year, while the fourth was not taken until January 29, 1959.

Table 4. Dates of Birth and Death for Females in the Two Corrals

Female	Date of birth	Date of death
Old corral		
Original doe A	June , 1953	January 27, 1957
Original doe B	June , 1953	February 1, 1957
Fawn 1	May 7, 1955	January 30, 1956
Fawn 2	May 7, 1955	January 30, 1956
Fawn 3	August 1, 1955	January 26, 1957
Fawn 4	May 10, 1956	January 27, 1957
Fawn 5	June 10, 1956	November 12, 1959
Fawn 6	June 10, 1956	November 12, 1959
Fawn 7	June 1, 1958	August 25, 1959
Fawn 8	June 1, 1958	November 12, 1959
Fawn 9	June 1, 1958	February 19, 1960
Fawn 10	June 1, 1959	November 12, 1959
Fawn 11	June 1, 1959	February 23, 1960
Fawn 12	June 1, 1959	February 23, 1960
New corral		
Original doe A	June , 1953	January 29, 1959
Original doe B	June , 1953	August 16, 1959
Fawn 1	June 10, 1955	January 18, 1956
Fawn 2	May 25, 1956	January 26, 1957
Fawn 3	June 25, 1956	January 26, 1957

In 1958 three fawns (all males) were born. One pair, born about July 28, were shot on January 28 and 29, 1959. The other, born about August 28, was shot on January 28, 1959.

The two original does were removed on January 29, 1959. One, killed accidentally, had two male embryos. The other gave birth to twins, a male and a female, at the Delmar Game Farm about June 18–20, 1959.

Four female fawns were produced in the new corral; three provided breeding data. None of these became pregnant during its first year, and all were removed before they had another opportunity. There were 10 pregnancies among the adult does. These resulted in 18 fawns or embryos, an average of 1.8 per doe. Nine pregnancies produced 16 fawns that survived, an average of 1.8; and one produced two embryos. All could be sexed; 14 were males and four were females.

The dates of birth and death for the females in both corrals are given in Table 4.

Weight

The live weights of each of the original deer from The Plains, when liberated in the corrals and when removed, together with the weight of each fawn at the time it was removed are given according to age in Table 5. These weights are also plotted for the two sexes in Figure 1.

The mean weight of the four original male fawns (average age 8.4 months) was 53.5± 11.8 pounds and that of the four original female fawns (average age 8.7 months) was 50.6± 7.2 pounds. For their progeny, the mean weight of the eleven male fawns (average age 6.2 months) was 75.1± 14.4 pounds and that of the nine female fawns (average age 7.9 months) was 77.8± 11.1 pounds. When weighed, the progeny averaged younger than the original stock, but they averaged 21.6 pounds heavier for the males and 27.2 pounds heavier for the females. Tested statistically, the greater weights of the progeny were highly significant.

There were too few weights for adult deer (1½ years and older) for analysis. However, the graphs indicate that, as adults, the male progeny weighed about the same as, if not slightly more than, the original deer and that the female progeny were heavier than the original deer.

Density

The number of deer-days for the 100- and 131-day winter seasons (when the deer were largely dependent on browse for nutrition) and

the densities each year in terms of deer per day per square mile are given in Table 6. The average densities for each corral differed only slightly, whether the 100-day or the 131-day season is considered. However, the density was low during the first winter (1953–54) in both corrals because the deer were not liberated until February. It was low in the old corral during 1957–58 because only two deer were present all winter. It was also low during the last winter in the new corral because all deer were removed in January 1959, but deer were in the old corral throughout the winter of 1958–59.

With these exceptions, the winter densities were sufficiently high that virtually all the available browse was utilized. This should not be construed to mean that greater densities could not have been sustained for a few years. But, higher densities of deer and the attendent greater demands for feed would probably have resulted in overbrowsing of the better quality browse species. This would have started a decline in the quality and quantity of browse produced in subsequent years.

Table 5. Recorded Live Weights for the Deer in the Two Corrals

Age*	Original Deer		Progeny		Date weighed
	Male	Female	Male	Female	
Old corral					
0–5½	..	..	..	100	November 12, 1959
0–5½	..	..	85	..	November 12, 1959
0–7½	..	..	82	..	January 26, 1957
0–8	68	..	..	..	February 2, 1954
0–8¼	39§	..	..	..	February 8, 1954
0–8¼	..	59	..	..	February 8, 1954
0–8½	..	54§	..	..	February 18, 1954
0–8½	..	..	..	72	January 27, 1957
0–8¾	..	..	..	85	January 30, 1956
0–8¾	..	..	..	86	January 30, 1956
0–8¾	..	..	..	77	February 23, 1960
0–8¾	..	..	..	78	February 23, 1960
1–3	..	..	..	137½	August 25, 1959
1–5½	..	..	..	125	November 12, 1959
1–6	..	..	..	123	January 26, 1957
1–6	..	..	134	..	February 1, 1957
1–8½	..	..	..	90	February 19, 1960
3–5	..	..	..	135	November 12, 1959
3–5	..	..	..	160	November 12, 1959
3–8	..	135§	..	..	January 27, 1957
3–8	150§	..	..	..	January 28, 1957†
3–8	..	130	..	..	February 1, 1957
3–8	188	..	..	..	February 1, 1957
4–5½	181§	..	..	..	November 13, 1957

TABLE 5. (*continued*)

Age*	Original Deer		Progeny		Date weighed
	Male	Female	Male	Female	
			New corral		
0–4¾	..	..	88	..	November 13, 1957
0–5	..	..	92	..	October 23, 1957
0–5	..	..	85	..	October 23, 1957
0–5	..	..	53‡	..	January 28, 1959
0–6	..	..	61	..	January 28, 1959
0–6	..	..	51	..	January 29, 1959
0–7	..	..	72	..	January 26, 1957
0–7	..	..	..	65	January 26, 1957
0–7¼	..	..	..	69	January 18, 1956
0–7½	..	..	85	..	January 18, 1956
0–8	..	..	..	68	January 26, 1957
0–8	..	..	72	..	January 26, 1957
0–8	54	..	..	..	February 8, 1954
0–9	53§	..	..	..	February 26, 1954
0–9	..	46½	..	..	February 26, 1954
0–9	..	43§	..	..	February 26, 1954
1–7	..	..	129	..	January 29, 1959
2–7½	141§	..	..	..	January 9, 1956
3–8	..	..	164	..	January 29, 1959
5–8	124	..	..	..	January 28, 1959
5–8	..	118‡	..	..	January 29, 1959
5–8	..	125§	..	..	January 29, 1959

* In years and months.
§ In each column, represent records for same deer.
† Trapped, weighed and released on this date.
‡ Calculated from dressed weights of 39 pounds for fawn and 90 pounds for adult.

SEX RATIO

There were 38 embryos or fawns produced for which sex could be determined. The sex ratio differed widely in the two corrals, being 4 males to 16 females in the old corral and 14 males to 4 females in the new corral. However, the combined production of 18 males to 20 females was not significantly different from a ratio of 106.2 males to 100 females which was reported by Severinghaus and Cheatum (1956) to be the average for the species with respect to fawns between 5 and 7 months of age. There were also four unsexable embryos. If these had been predominantly male, the ratio would have been even closer to the average.

RELATIONSHIP OF CORPORA LUTEA TO FAWNS BORN

As a general rule, the number of fawns born to the does of a

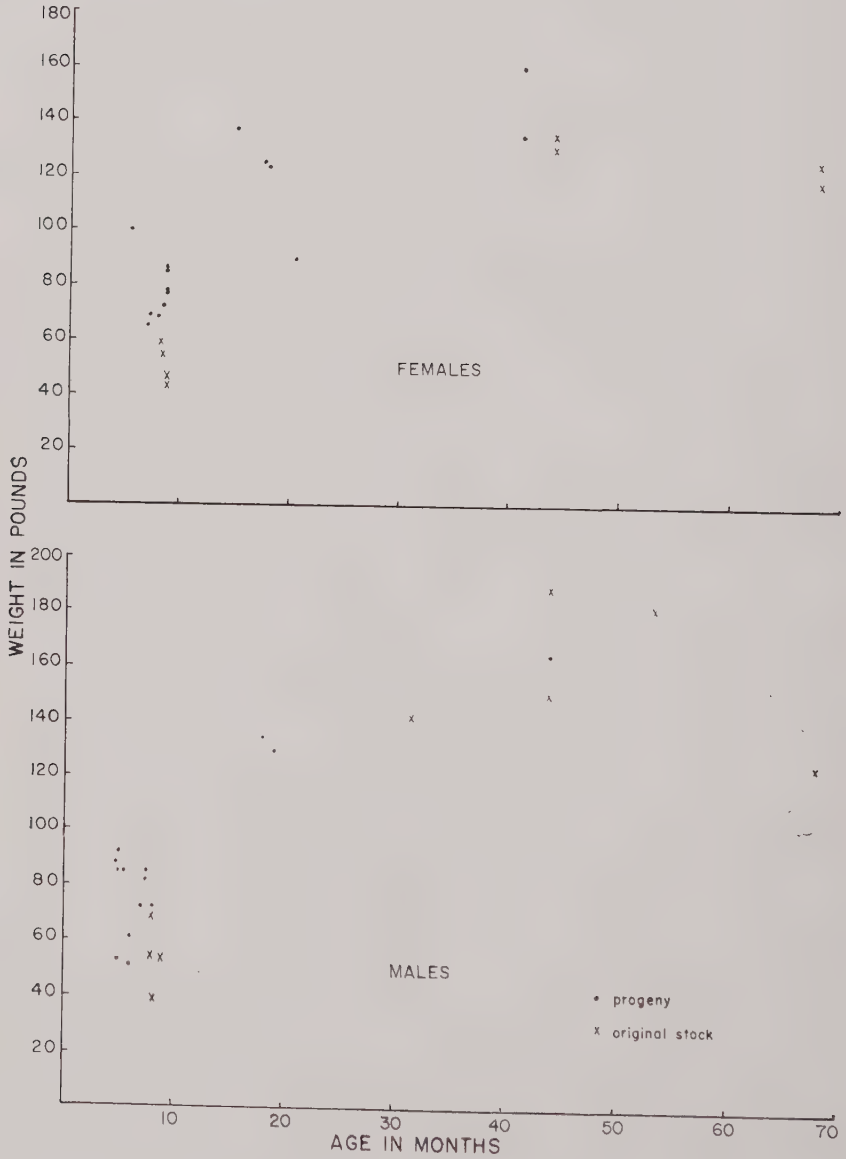

Figure 1. Live weights in relation to age for the deer in the two corrals.

deer population is something less than the number of corpora lutea associated with them. And the number of corpora lutea is something less than the number of eggs shed. Of interest are three instances during the present study in which all the eggs shed were fertilized and developed into fawns that lived. One of the original does produced triplets in June 1956, and when she was shot on February 1,

TABLE 6. DENSITY OF DEER IN THE TWO CORRALS

Winter	Old corral		New corral	
	Total deer-days	Density*	Total deer-days	Density*
	100-day winter season			
1953–54	(228)§	(17.0)§	(178)§	(20.0)§
1954–55	408	30.4	408	45.8
1955–56	714	53.3	621	69.8
1956–57	404	30.1	609	68.4
1957–58	228	17.0	570	64.0
1958–59	648	48.4	(230)§	(25.8)§
Average	480	35.8	552	62.0
	131-day winter season			
1953–54	(228)§	(13.0)§	(178)§	(15.3)§
1954–55	532	30.3	532	45.6
1955–56	962	54.8	838	71.9
1956–57	683	38.9	888	76.2
1957–58	321	18.3	725	62.1
1958–59	831	47.5	(478)§	(41.0)§
Average	666	38.0	746	64.0

* Deer per day per square mile.
§ Did not represent full winter season and not included in average.

1957 her ovaries contained three corpora albicans. Two other does produced four fawns in June 1959, and when they were shot on November 12, 1959 the ovaries of each had two corpora lutea.

DISCUSSION

Other studies (Cheatum and Severinghaus, 1950; Severinghaus, 1955) have shown that deer from the central Adirondacks where much of the winter range is severely overbrowsed have a lower reproductive rate and weigh less than deer from central and western New York where the winter range is generally in good condition. This experiment was undertaken to determine whether deer from a population that had existed for many years in a central Adirondack area affording poor winter range were inherently different, with respect to reproduction and growth, than deer from the better quality range of southern New York.

For test specimens, fawns were obtained from one of the most deteriorated wintering areas in the central Adirondacks where substantial winter starvation had been chronic for some three-quarters of a century. These fawns, trapped in February, averaged 17½

pounds (or about 25 per cent) less in weight than fawns in this area weigh during late October and November. Thus they were typical of the deer the experiment was designed to study.

During the period they were under study in the corrals, the transferred females reproduced at an average rate of 1.88 progeny per pregnancy after they were a year old. Most of the female fawns produced in the corrals were removed before they had an opportunity to breed as adults. Five that did have such opportunity, all in the old corral which had the poorer browse supply, averaged 1.33 progeny per pregnancy. The combined rate was 1.75 which is virtually identical to the average of 1.71 for deer on the good ranges of western New York and is far superior to that of 1.06 for the central Adirondacks as reported by Cheatum and Severinghaus (1950). Therefore, the data indicate no inherent lack of reproductive potential for the Adirondack deer.

Data from southern New York[3] have shown that, when deer have adequate nutrition, 25 to 45 per cent of the female fawns breed successfully during their first year. In the corrals 14 fawns had an opportunity to breed, but only one (7 per cent) became pregnant. This low rate, in contrast to the high rate among the adults, indicates that the available nutrition in the corrals was to some extent inadequate.

Live weights of fawns from the wilderness areas of the central Adirondacks average 71 pounds for males and 68 pounds for females in late October and November, i.e., when they are 4½ to 6 months old. Five males of comparable age that were born in the corrals averaged 81 pounds, and one female weighed 100 pounds. Thus with better forage, the progeny of the original deer grew at a faster rate than is characteristic of deer in the area from which the stock came.

As has been mentioned, some 1,000 to 2,000 deer wintered in the 14- to 15-square mile area of The Plains in the Adirondacks during the 1940's. This would represent densities of 65 to 140 deer per square mile of winter range. The area was severely overbrowsed and starvation losses ran as high as 20 per square mile. The experiments in the corrals showed approximately what densities could be supported without deterioration of the browse supply. The old corral, which had been virtually browsed out in 1946, provided sufficient nutrition for only about 35 to 38 deer per square mile. The new corral had a much greater browse supply which included hemlock and could support 62 to 64 deer per square mile. There seems little doubt that

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[3] Unpublished data collected by Federal Aid Projects W-1-R-Supp C, W-35-R and W-89-R.

at the low population level of 1,000 deer, the wintering area of The Plains had been considerably overstocked. When 2,000 deer were present, three to four times the amount of available browse would have been required to provide adequate food.

The results of this study demonstrate that deer from even the poorest range in the Adirondacks are not inherently different from deer elsewhere in the State. When transferred to good range, such stock exhibited rates of reproduction and growth fully comparable to those of deer already established there. It seems clear that adequacy of nutrition is the primary factor responsible for differences that occur.

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FEEDING HABITS OF THE SUMMER FLOUNDER IN GREAT SOUTH BAY[1]

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ABSTRACT

Stomachs from 1,210 summer flounder collected in Great South Bay in the summers of 1958 and 1959 were examined. These fish had fed on a wide variety of organisms, but mainly upon sand shrimp and winter flounder. Analysis of the data indicated that feeding activity remains constant throughout the summer. Therefore, the major seasonal fluctuations of the sport fishery for summer flounder cannot be attributed to seasonal changes in feeding activity.

Recently published statistics of the sport fishery in Great South Bay (Briggs, 1962) indicated the importance of the summer flounder (*Paralichthys dentatus*) to the salt-water angler. Among other things, these statistics showed that, in the years from 1956 through 1960, 55 to 91 per cent of the anglers' catch in the bay during the period from June through September was composed of summer flounder. Annual landings in the bay by sportsmen fluctuated from 791,000 to 1,800,000 fish. These annual fluctuations were shown to have been largely the result of the bay fishery's dependence upon 1-year-old fish (Poole, 1961).

The statistics of the sport fishery also demonstrated that a decline in this fishery generally occurred in the latter part of the summer. In 1956, 1957, 1959 and 1960, peak landings were recorded in either June or July, after which catches declined sharply. The landings during 1958 followed a different pattern; catches increased each month to a seasonal high in August. Catch per effort closely paralleled these seasonal fluctuations in catch.

Recent analysis of tag returns from summer flounder indicated that heavy early-season fishing was an important factor in the late-season decline of the sport fishery in Great South Bay (Poole, 1962). In 1956 and 1959, for example, when 25 per cent and 30 per cent, respectively, of the summer flounder calculated to have been present in the bay were caught by anglers in June and July, reduced landings occurred in August. In 1958, however, only 14 per cent of the calculated population was removed by sport fishermen in the early summer months. August landings in that year were the season's highest.

Factors other than early-season fishing may influence in some degree seasonal changes in the landings of summer flounder by the

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[1] A contribution of Federal Aid in Fish and Wildlife Restoration Project F-15-R. The author is indebted to Dr. Thomas E. Bowman of the Smithsonian Institution for the identification of opossum shrimp (*Neomysis americana*).

sport fishery. This possibility prompted an investigation of the feeding habits of this fish and a comparison of feeding activity with catch statistics of the sport fishery.

METHODS

Summer flounder were collected by otter trawl in 1958 and 1959 at four stations within Great South Bay (Figure 1). Two stations were located down-bay in 10 and 20 feet of water; the other two were up-bay in depths of 10 feet. On each collecting trip, the trawl was set for 15 minutes at each station. In the two years of the study, on

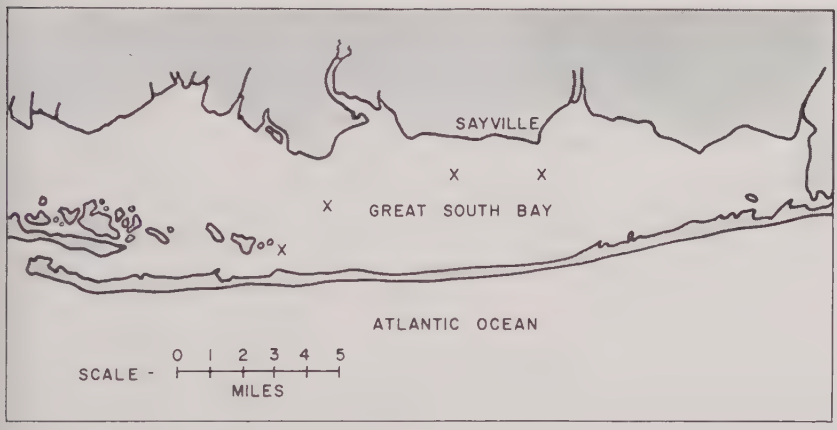

Figure 1. Locations of the four stations (X) at which trawl sets for summer flounder were made.

one collecting trip only, one station was not sampled. In order to eliminate from analysis the possible effects of varying tidal stage on feeding activity, all trawl sets were made as close as possible to daytime high tide. This was accomplished by beginning each collecting day at the down-bay stations at high tide and proceeding with the tide to the up-bay stations. In 1958, there were 12 collecting trips in the period from June 5 through October 7, and 47 trawl sets were made. In 1959 there were 15 collecting trips in the period from June 5 through September 28, and 60 trawl sets were made.

All summer flounder taken by trawl were kept for examination. For each fish, the following information was recorded: the date, station, total length in centimeters and sex of the fish; and the weight in grams of each food item by species. The data were subsequently separated by season so that feeding activity during the early season might be compared with that during the late season. Further separation of data was not necessary, since tag returns from marked summer

flounder previously reported by Poole (1962) had demonstrated that the fish which enter the bay in May and June remain in the bay until late September and October. The returns also showed that summer flounder present in the ocean do not supplement the population after June. Therefore, early-season and late-season populations in the bay are similar. In 1958, the data were separated into the periods June 5 through July 29 and August 6 through October 7. In 1959 corresponding divisions were made for the periods June 5 through July 21 and August 3 through September 28. In 1958, equal numbers of collecting trips were made in the two periods. In 1959, eight trips were taken in the early period, seven in the later period.

DISCUSSION

In 1958, stomachs of 387 summer flounder were examined, and 823 were examined in 1959. In both years, females outnumbered males, 140 to 100 in 1958 and 270 to 100 in 1959. Chi square analysis indicates that in each case the difference from a 1:1 sex ratio was highly significant ($P < 0.005$). There also were differences in the size composition of the population between years (Figures 2 and 3).

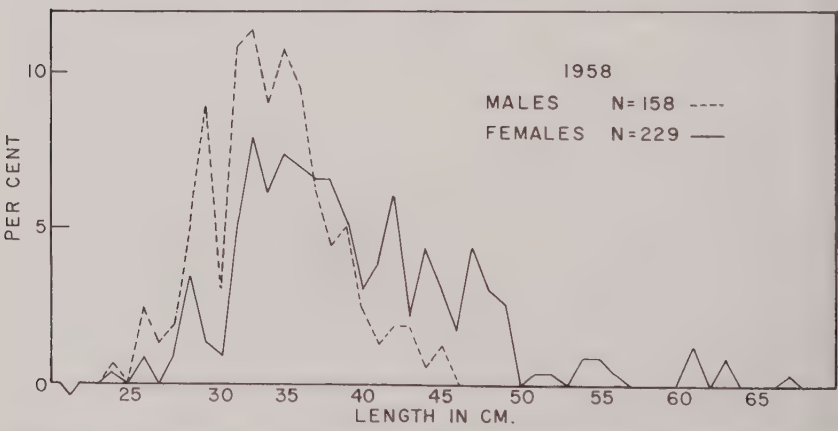

Figure 2. Size composition of the summer flounder population in Great South Bay in 1958 as represented by the length-frequency distribution of specimens collected.

This was due to a predominance of 1-year-old female fish in 1959 and a more even contribution of 1-, 2-, and 3-year-old females in 1958. In both years, the male fish consisted largely of 1- and 2-year-olds.

The data collected demonstrate that the summer flounder fed primarily upon sand shrimp (*Crangon septemspinosa*) and winter flounder (*Pseudopleuronectes americanus*). Because the feeding habits during the two summers differed markedly only in respect to the

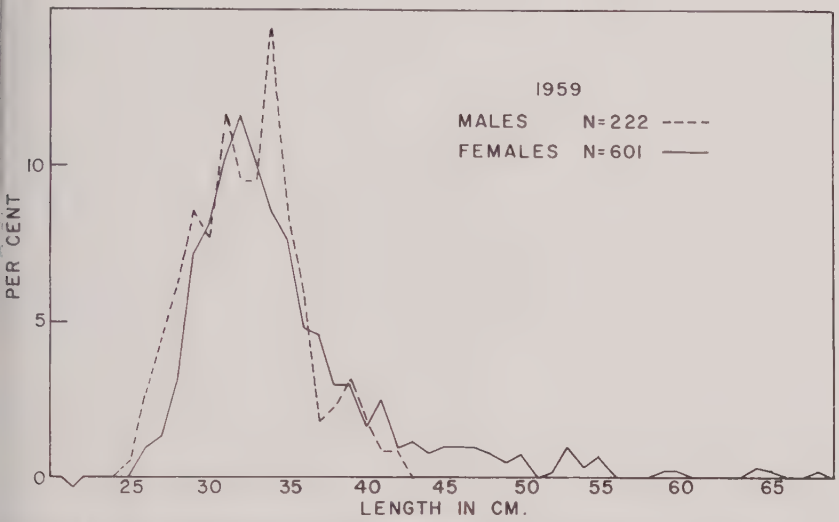

Figure 3. Size composition of the summer flounder population in Great South Bay in 1959 as represented by the length-frequency distribution of specimens collected.

TABLE 1. RELATIVE IMPORTANCE BY WEIGHT AND BY FREQUENCY OF OCCURRENCE FOR FOODS EATEN BY 806 SUMMER FLOUNDER FROM GREAT SOUTH BAY IN THE SUMMERS OF 1958 AND 1959*

Food §	Weight		Occurrence	
	Grams	Per cent	Number †	Per cent
Sand shrimp	1,010	28.5	436	54.1
Winter flounder	987	27.8	60	7.4
Blue-claw crab	431	12.1	34	4.2
Opossum shrimp	344	9.7	189	23.4
Northern pipefish	292	8.2	87	10.8
Atlantic menhaden	129	3.6	6	0.7
Bay anchovy	92	2.6	34	4.2
Unidentified fish	85	2.4	30	3.7
Unidentified pelecypods	48	1.4	47	5.8
Squirrel hake	39	1.1	2	0.2
Atlantic silverside	36	1.0	13	1.6
American sand lance	17	0.5	1	0.1
Unidentified gastropods	14	0.4	1	0.1
Bluefish	11	0.3	2	0.2
Weakfish	8	0.2	1	0.1
Mummichog	6	0.2	2	0.2

* Of the 1,210 stomachs collected, 404 (33.4 per cent) were empty.
§ Includes only items totaling more than 5 grams in weight.
† Number of stomachs in which food item was found.

blue-claw crab (*Callinectes sapidus*), the data were combined (Table 1). In 1958, blue-claw crabs were eaten frequently, and the weight of those eaten was greater than that of any other organism in that summer. In 1959, a blue-claw crab occurred in only one summer flounder stomach. Both soft-shelled and hard crabs were eaten. The winter flounder found in the stomachs were young of the year and 1-year-olds. Other than these species, the summer flounder fed upon a wide variety of organisms. These included the following in decreasing order of importance as indicated by their weight in the stomachs examined; opossum shrimp (*Neomysis americana*); northern pipefish (*Syngnathus fuscus*); Atlantic menhaden (*Brevoortia tyrannus*); bay anchovy (*Anchoa mitchilli*); unidentified bivalve molluscs; squirrel hake (*Urophycis chuss*); Atlantic silverside (*Menidia menidia*); American sand lance (*Ammodytes americanus*); unidentified gastropod molluscs; bluefish (*Pomatomus saltatrix*); weakfish (*Cynoscion regalis*); mummichog (*Fundulus heteroclitus*); mud crabs (Family Xanthidae); hermit crabs (*Pagurus* sp.); unidentified sea squirts; unidentified isopods; grubby (*Myoxocephalus aeneus*); and horseshoe crab (*Limulus polyphemus*).

Bigelow and Schroeder (1953) reported that the summer flounder is a predaceous fish which feeds upon smaller fish, squids, crabs, shrimps, small shelled molluscs, worms and sand dollars. They did not record where the examined fish were taken, although the reporting of sand dollars as a food item indicates that they were captured in the ocean. If they were, comparison with the data for summer flounder taken in Great South Bay suggests that there is a similarity of feeding habits in bay and ocean waters.

In order to investigate feeding activity in the early season and late season, analyses were made of the proportion of stomachs containing food for the two summer periods. No significant differences (0.05 criterion) were found for either year. To investigate this further, tests of significance were applied to the mean weights of the stomach contents. There was no significant difference (0.05 criterion) in mean weights in 1958, but there was a significant difference ($P=0.035$) in 1959. There is evidence, then, that feeding activity was the same throughout both summers. Data pertaining to these analyses are given in Table 2.

Examination of the catch and the catch per effort of the sport fishery for summer flounder reveals that these statistics were not constant over the summer (Tables 3 and 4). As described previously, there were peaks in each summer. Data for 1959 demonstrated more marked seasonal fluctuations than those for 1958, particularly with respect to catch per effort. Since feeding activity was the same throughout the summer period and catch statistics fluctuated seasonally, it

TABLE 2. DATA USED IN COMPARING EARLY-SEASON WITH LATE-SEASON FEEDING ACTIVITY OF SUMMER FLOUNDER IN GREAT SOUTH BAY

Item	1958		1959	
	Early season	Late season	Early season	Late season
Stomachs examined	185	202	597	226
Stomachs containing food				
Number	126	119	409	152
Per cent	68	59	69	67
Mean weight of stomach contents				
Grams	5.67	6.80	3.78	5.21
Standard deviation	6.19	8.93	6.15	7.62

TABLE 3. MONTHLY CATCH OF SUMMER FLOUNDER (IN NUMBERS OF FISH) TAKEN BY THE SPORT FISHERY IN GREAT SOUTH BAY IN 1958 AND 1959

Month	1958	1959
May	3,982	96,081
June	319,138	608,425
July	426,491	554,067
August	552,848	279,815
September	209,853	96,245

TABLE 4. MONTHLY CATCH PER EFFORT BY PRIVATE BOAT FISHERMEN FOR SUMMER FLOUNDER IN GREAT SOUTH BAY IN 1958 AND 1959

Month	1958	1959
May		6.2
June	7.0	10.7
July	5.5	8.8
August	5.7	3.3
September	5.4	3.7

is apparent that feeding activity did not have a controlling influence upon the large seasonal fluctuations of the sport fishery for summer flounder.

CONCLUSIONS

Comparison of the feeding activity of summer flounder, which is mainly directed toward sand shrimp and winter flounder, and the catch statistics of the sport fishery in Great South Bay reveals no

correlation between the two. It is evident, then, that major seasonal fluctuations in the catch of summer flounder by the sport fishery cannot be attributed to changes in feeding activity.

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EXPERIMENTAL CONTROL OF PURPLE LOOSESTRIFE (*LYTHRUM SALICARIA*)[1]

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ABSTRACT

Trial plots of purple loosestrife were treated with various herbicides. Control, but not eradication, was best obtained by foliar applications of water solutions or oil and water emulsions of the so-called low-volatility esters of 2, 4, 5-T or 2, 4-D and 2, 4, 5-T in mixture, or silvex, at a concentration of 8 pounds acid equivalent per acre when at least 200 gallons of total solution were applied per acre. Satisfactory control did not result from treatment with various amine salts of 2, 4-D, the isooctyl ester of 2, 4-D, a formulation of 2, 3, 6-TBA, amitrole, or ammonium sulfamate.

This study was made at the request of game management personnel who had found the purple loosestrife to be an aggressive, persistent, unwanted weed in small marshes being created in the Hudson-Mohawk Valley and in the Ontario Lake Plain of New York State. Purple loosestrife (*Lythrum Salicaria*) is a tall perennial herb, introduced from Europe before 1860, and now occurring in great abundance in shallow marshes, wet meadows and along the margins of streams, ponds and lakes from Quebec and the New England states west to Michigan and south to Maryland. It tends to form clumps, with annual growths reaching to 6 feet and standing after death for several seasons. Its terminal spikes of red-purple flowers are attractive in appearance, so that large-flowered forms are offered for sale as ornamentals. It spreads readily by seed, particularly where the shallow margins of water areas are exposed by lowered water levels in late spring, summer and fall. It will survive for many years even when submerged to depths of 2 or 3 feet, so that in the wildlife marsh, with average water depths of 12 to 18 inches, purple loosestrife can take over and occupy much water area that should be occupied by waterfowl food plants. Where cattail marshes are not present, its dense growth serves as shelter and escape cover for pheasants and cottontail rabbits.

Previous attempts to control purple loosestrife have been described by McKeon (1959) who reported that on a marsh in Dutchess County (N. Y.) manipulating water levels, burning dead loosestrife clumps in winter and cutting clumps at or below the surface did not destroy the plants. Applications of water solutions of (1) the alkanolamine

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[1] A contribution of Federal Aid in Fish and Wildlife Restoration Project W-88-R. The 2, 4-D isooctyl ester used in 1957 was supplied by Chemagro Corp., New York, N. Y., and the 2, 4-D butoxyethanol ester, invert formulation used in 1959 and 1960 was supplied by Amchem Products, Inc., Ambler, Pa.

salts of 2, 4-D, (2) a water-soluble salt of amitrole, (3) a mixture of the alkanolamine salts of 2, 4-D and 2, 4, 5-T, and (4) propylene glycol butyl ether esters of silvex[2] resulted in killing, to various degrees, the tops of the loosestrife. Plots treated with amitrole, 2,4-D, and the mixture of 2,4-D and 2,4,5-T had an abundant regrowth of loosestrife in the following season. Treatments with diuron were considered ineffective. The amount of regrowth from plants treated with silvex was not reported.

Smith (1959) reported complete control of loosestrife plants on the Montezuma National Wildlife Refuge that were treated with ammonium sulfamate at the rate of 32 to 40 pounds of active ingredient per acre applied by means of a power sprayer. Hand pulling of scattered plants growing in water was considered feasible. Plants on dry sites could be removed completely by hand pulling. Rapid invasion of impoundment areas by loosestrife seedlings whenever the water was drawn off was noted.

METHODS

An area known as the storage pond, on the north side of the Howland Island Game Management Area, was chosen for the trials because it was the largest area of loosestrife available and because each year the water which was about 2 feet deep in spring dropped slowly until the ground was nearly dry by the middle of August.

Treatments in 1956

Plots were laid out and treated on July 23 and 24, 1956 along a series of parallel, shallow ditches which made openings in the loosestrife stand. Herbicides were applied as over-all foliage and stem sprays, using a 4-gallon high pressure knapsack sprayer and covering roughly 1/10 acre in all along the sides of each ditch, to give an application rate of about 50 gallons of solution per acre. Carriers were either pond water or #2 fuel oil. The herbicides used are listed in Table 1, part A. They were applied at an acid equivalent rate of 8 pounds per acre.

In addition, isolated clumps of loosestrife were sprayed only on

[2] In many cases, the complex compounds used as herbicides have been given shortened designations or trade names. Throughout this paper these will be used as follows:

2, 3, 6-TBA	2, 3, 6-trichlorobenzoic acid
2, 4-D	2, 4-dichlorophenoxyacetic acid
2, 4, 5-T	2, 4, 5-trichlorophenoxyacetic acid
amitrole	3-amino-1, 2, 4-triazole
atrazine	2-chloro-4-ethylamino-6-isopropylamino-s-triazine
dalapon	2, 2-dichloropropionic acid
diuron	3- (3, 4-dichlorophenyl) -1, 1-dimethylurea
fenuron	3-phenyl-1, 1-dimethylurea
silvex	2- (2, 4, 5-trichlorophenoxy) propionic acid

the stems, down to the water line, to see if the solutions would penetrate the swelling of spongy tissue that develops from the base of the plant to a point well above the water line.

On August 24 the treated plots were examined to determine the degree to which the tops of the plants had been killed and whether any sprouting from the base of the stems had occurred. On August 1 and 2, 1957, the plots were again examined to determine the effectiveness of the treatments.

TREATMENTS IN 1957

On August 1 and 2, 1957, when the loosestrife had been in flower for some time, additional plots, approximately 1/25 acre in size, were laid out and treated with herbicides as shown in Table 1, part B. Materials used for the first time included the isooctyl ester of 2,4-D and a wettable powder formulation of amitrole. At this time the pond was nearly dry. On September 5 the plots were examined to determine the degree of control of the tops of the plants and whether they were sprouting again from the base. The plots were reexamined in the summer of 1958.

TREATMENTS IN 1958

Because resprouting from the base of the treated loosestrife plants was so abundant in the summer of 1958, herbicide applications were delayed until September 17 and 25, to see if late treatment would prevent resprouting. Plots, 21 feet square and representing approximately 1/100 acre, were laid out by cutting the loosestrife in a strip 3 feet wide around each. Treatment was done at the same rates and by the same methods as in previous seasons using the herbicides listed in Table 1, part C. Only the first plot was treated on the 17th when a rainy period halted work until the 25th when treatments were completed. Because of the late treatment, no evaluation of results for the season could be made, but observations were made the following year in July.

TREATMENTS IN 1959

On August 14, 1959 an additional 12 plots, each approximately 1/100 acre in size, were laid out by cutting a strip 3 feet wide around each. Two plots, selected at random, were left as controls while the others were treated as shown in Table 1, part D. The amount of herbicidal solution was increased, from the 50 gallons per acre previously used, as shown in the table. The emulsions, prepared with the aid of an emulsifier, were 20 per cent oil and 80 per cent water. The

Table 1. Herbicides Used and Their Effectiveness in Controlling Purple Loosestrife on the Howland Island Game Management Area, 1956-1961

Herbicide	Application *		Control †		
	Rate §	Carrier	Initial top kill	Resprouting same season	Kill a year later
(A) 1956					
2,4-D, butoxyethanol ester	8	water	9	9	5
2,4-D, dimethylamine salt	8	water	9	5	2
2,4-D, dimethylamine salt	8	#2 fuel oil	5	5	2
2,4-D, propylene glycol butyl ether esters	8	water	7	8	2
2,4-D, propylene glycol butyl ether esters	8	#2 fuel oil	8	8	2
2,4,5-T, propylene glycol butyl ether esters	8	water	9	9	5
2,4,5-T, propylene glycol butyl ether esters	8	#2 fuel oil	9	8	5
2,4-D and 2,4,5-T, propylene glycol butyl ether esters	4–4	water	9	9	5
2,3,6-TBA	8	water	5	5	2
2,3,6-TBA	8	#2 fuel oil	5	5	2
silvex	8	water	10	9	5
silvex	8	#2 fuel oil	9	8	5
(B) 1957					
2,4-D, butoxyethanol ester	8	water	8	5	2
2,4-D, butoxyethanol ester	8	#2 fuel oil	8	5	2
2,4-D, isooctyl ester	8	#2 fuel oil	8	5	2
2,4-D, propylene glycol butyl ether esters	8	water	8	5	2
2,4-D, propylene glycol butyl ether esters	8	#2 fuel oil	8	5	2
2,4,5-T, propylene glycol butyl ether esters	8	water	10	8	5
2,4,5-T, propylene glycol butyl ether esters	8	#2 fuel oil	10	8	5
2,4-D and 2,4,5-T, propylene glycol butyl ether esters	4–4	water	10	8	5
2,4-D and 2,4,5-T, propylene glycol butyl ether esters	4–4	#2 fuel oil	10	8	5
silvex	8	water	10	8	5
silvex	8	#2 fuel oil	10	8	5
amitrole	6	water	2	2	0
(C) 1958					
2,4-D, butoxyethanol ester, invert emulsion	8	oil-water 10 to 88	..	..	2
2,4,5-T, propylene glycol butyl ether esters	8	water	..	..	2
2,4,5-T, propylene glycol butyl ether esters	8	oil-water 1 to 4	..	..	2

TABLE 1. *(continued)*

Herbicide	Application *		Control †		
	Rate §	Carrier	Initial top kill	Resprouting same season	Kill a year later
(C) 1958 *(cont'd)*					
2,4-D and 2,4,5-T, propylene glycol butyl ether esters	4–4	oil-water 1 to 4	..	..	2
2,4-D and 2,4,5-T, propylene glycol butyl ether esters	4–4	#2 fuel oil	..	..	2
2,3,6-TBA	8	oil-water 1 to 4	..	..	2
silvex	8	water	..	..	2
silvex	8	oil-water 1 to 4	..	..	2
amitrole	50	water	..	..	1
ammonium sulfamate	50	water	..	..	0
amitrole and ammonium sulfamate	50–50	water	..	..	0
dalapon	50	water	..	..	0
(D) 1959					
2,4-D, butoxyethanol ester, invert emulsion (100 gallons per acre)	4	oil-water	10	9	8
2,4,5-T, propylene glycol butyl ether esters (300 gallons per acre)	8	water	10	9	8
2,4,5-T, propylene glycol butyl ether esters (200 gallons per acre)	8	oil-water	10	9	8
2,4-D and 2,4,5-T, propylene glycol butyl ether esters (200 gallons per acre)	4–4	oil-water	10	9	8
2,4-D and 2,4,5-T, propylene glycol butyl ether esters (200 gallons per acre)	4–4	water	10	9	8
silvex (300 gallons per acre)	8	water	10	9	8
silvex (200 gallons per acre)	8	oil-water	9	8	5
amitrole (300 gallons per acre)	100	water	5	5	5
ammonium sulfamate (300 gallons per acre)	100	water	5	5	2
amitrole and ammonium sulfamate (200 gallons per acre)	50–50	oil-water	5	5	2
(E) 1960 (re-treatment of plots treated in 1959)					
2,4-D, butoxyethanol ester, invert emulsion	4	oil-water	..	10	5
2,4,5-T, propylene glycol butyl ether esters	8	water	..	10	7
2,4,5-T, propylene glycol butyl ether esters	8	oil-water	..	10	7
2,4-D and 2,4,5-T, propylene glycol butyl ether esters	4–4	water	..	10	8
2,4-D and 2,4,5-T, propylene glycol butyl ether esters	4–4	oil-water	..	10	8
silvex	8	water	..	10	9
silvex	8	oil-water	..	10	

Table 1. (*continued*)

Herbicide	Application *		Control †		
	Rate §	Carrier	Initial top kill	Resprouting same season	Kill a year later
(E) 1960 (*cont'd.*)					
amitrole	100	water	..	8	5
ammonium sulfamate	100	water	..	5	4
amitrole and ammonium sulfamate	50–50	oil-water	..	8	4
(F) 1960					
2,4-D, alkanolamine salts	8	water	10	10	1
2,4-D, alkanolamine salts	8	oil-water	10	10	1
2,4-D, butoxyethanol ester, invert emulsion	8	oil-water	10	10	2
2,4-D, dimethylamine salt	8	water	10	10	7
2,4-D, dimethylamine salt	8	oil-water	10	10	1
2,4-D, isooctyl ester	8	water	10	5	2
2,4-D, isooctyl ester	8	oil-water	10	10	4
2,4-D, propylene glycol butyl ether esters	8	water	10	10	8
2,4,5-T, propylene glycol butyl ether esters	8	water	10	10	4
2,4,5-T, propylene glycol butyl ether esters	8	oil-water	10	10	10
2,4-D and 2,4,5-T, propylene glycol butyl ether esters	4–4	oil-water	10	10	2
silvex	8	water	10	10	8
silvex	8	oil-water	8	8	5
amitrole	50	water	9	9	6
ammonium sulfamate	50	water	5	5	2
(G) 1961 (re-treatment of plots first treated in 1960)					
2,4-D, alkanolamine salts	8	water	..	8	5
2,4-D, alkanolamine salts	8	oil-water	..	8	5
2,4-D, butoxyethanol ester, invert emulsion	8	oil-water	..	8	5
2,4-D, dimethylamine salt	8	water	..	5	2
2,4-D, dimethylamine salt	8	oil-water	..	2	2
2,4-D, isooctyl ester	8	water	..	1	1
2,4-D, isooctyl ester	8	oil-water	..	1	1
2,4-D, propylene glycol butyl ether esters	8	water	..	5	5
2,4,5-T, propylene glycol butyl ether esters	8	water	..	2	6
2,4,5-T, propylene glycol butyl ether esters	8	oil-water	..	8	8
2,4-D and 2,4,5-T, propylene glycol butyl ether esters	4–4	oil-water	..	8	8
silvex	8	water	..	5	5
silvex	8	oil-water	..	5	5
amitrole	50	water	..	2	1
ammonium sulfamate	50	water	..	2	1

TABLE 1. (*continued*)

Herbicide	Application *		Control †		
	Rate §	Carrier	Initial top kill	Resprouting same season	Kill a year later
(H) 1961 (quarter-acre plots)					
2,4-D and 2,4,5-T, propylene glycol butyl ether esters (200 gallons per acre)	2–2	oil-water	6	5	2
2,4-D and 2,4,5-T, propylene glycol butyl ether esters (50 gallons per acre)	3–3	oil-water	8	5	4
silvex (200 gallons per acre)	8	oil-water	8	5	4
silvex and atrazine (200 gallons per acre; applied August 31)	8–4	oil-water	10	10	9
fenuron (25-per cent pellets)	8	oil-water	2	1	1

* Application was at the rate of 50 gallons per acre for parts A, B and C; for part E it was the same as shown in part D, for part G it was the same as shown in part F; for part H the figures are given in the table.
§ Pounds acid equivalent per acre.
† In each case, figures represent ratings on a scale of 0 (no control) to 10 (complete control).

herbicide applied to each plot was also used to treat the bases of the plants in the cut-back border strips. On September 30 records were made of the degree of control obtained to that date, and subsequent observations were made in late August of 1960.

TREATMENTS IN 1960

Following evaluation of the control achieved, the plots were re-treated with the same solutions and at the same gallonage per acre as in 1959 (Table 1, part E). Also, one of the check plots was treated with the propylene glycol butyl ether esters of 2,4-D in water and the other was treated with the isooctyl ester of 2,4-D in water. Sixteen additional 1/100-acre plots were laid out by cutting a strip 3 feet wide around each. Three of these new plots were left untreated as checks while the others were treated with herbicides. Data for the plots treated for the first time are given in Table 1, part F. Application was at the rate of 200 gallons of solution per acre, using the procedures of the previous year. All plots were examined on October 20, 1960 and again on June 29, 1961.

TREATMENTS IN 1961

On June 29, 1961 all the plots treated for the first time in 1960

were re-treated, using the same materials and gallonage per acre (Table 1, part G), to control any surviving plants, sprouts or seedlings. In addition, four quarter-acre plots were treated on June 29, and a fifth plot was treated on August 31, with a mixture of silvex and the wettable powder formulation of atrazine (Table 1, part H). This last plot was in an area of loosestrife on ground that was merely damp at the time of treatment, so that the atrazine might have an opportunity to be effective. The plots treated in June were re-examined on August 31. All plots were examined on October 20, 1961 and again on July 12, 1962.

FINDINGS

There were wide variations in the degree to which growths of purple loosestrife were controlled by the herbicide treatments used. The results for each year's treatments are given separately.

Treatments in 1956

Observations on August 24, 1956 showed a satisfactory kill of the tops of loosestrife on the plots treated with 2,4-D and 2,4,5-T except in the case of the oil emulsion of the dimethylamine salt of 2,4-D (Table 1, part A). The latter may have resulted from inability to keep the 2,4-D in suspension. The two 2,3,6-TBA applications gave the least satisfactory kill. There was some sprouting from the base of at least a few plants in each plot. Only the silvex in water treatment resulted in killing all the tops. Observations on the plants of which only the stem bases had been sprayed showed that the spongy tissue had not been penetrated by either the oil or water preparations of the herbicides so that the tops were still uninjured. By August 1, 1957 there was vigorous growth of loosestrife in all plots treated in the previous season, so that the treated plants had tops nearly as high as those in the adjoining untreated areas.

Treatments in 1957

Observations made on September 5, on the plots treated on August 2, showed that, whereas the tops were killed completely by the treatments with silvex, 2,4,5-T, and the mixtures of 2,4-D and 2,4,5-T, there was resprouting from the bases of plants in all plots (Table 1, part B). Treatment with amitrole gave almost no top kill and resulted in abundant sprouting. By July 1958 all plots showed abundant resprouting, and by September 15 the loosestrife was full size again.

TREATMENTS IN 1958

Because of the delay until September 25 in treating the plots, only the preliminary effects on the tops of the loosestrife could be observed during that season. The 2,4-D, 2,4,5-T and silvex treatments apparently killed the plants down to their bases. Amitrole, dalapon, ammonium sulfamate and 2,3,6-TBA had not done so by the time of the first killing frost in October. In July 1959, observations showed that none of the late summer treatments of the previous year had given control (Table 1, part C). There was sprouting from the base of nearly every plant, so that there was vigorous growth and flowering.

TREATMENTS IN 1959

Observations made on September 30, 1959, on the plots treated on August 14, showed a complete or nearly complete kill of the tops of the loosestrife except for those treated with amitrole, ammonium sulfamate, and the mixture of these two herbicides (Table 1, part D). In the latter three instances nearly half the loosestrife tops were still alive and flowering. On the plot treated with silvex in oil and water emulsion a group of five stems was left uninjured. One or two sprouts were noted in each plot on this date. By August 5, 1960, sprouts were found on at least one, but not more than three, plants in each of the plots treated with the various 2,4-D and 2,4,5-T formulations and the silvex in water solution. This was a considerable change from the results obtained in previous seasons. Since the herbicides tested were the same, with one exception, as those used in the previous treatments, the only variation that would seem to account for the improved results was the increase in amount of solution used from 50 gallons per acre to 100, 200 and 300 gallons per acre.

TREATMENTS IN 1960

Re-treatment in 1960 of the plots that were treated in 1959, using the same materials as in the previous year, resulted in complete control of resprouting except on the plots treated with amitrole, ammonium sulfamate and the mixture of these two compounds where resprouting had occurred by the following October 20 (Table 1, part E). On June 29, 1961, observations on these plots, on which the loosestrife was then standing in water 18 to 24 inches deep, all contained at least one plant sprouting from the base plus various numbers of seedlings. The silvex in water solution provided the best results, with only two sprouts noted on the plot. The mixture of 2,4-D and 2,4,5-T provided almost as good control of sprouting. Treatments with

amitrole and ammonium sulfamate were quite ineffective, since they left entire clumps of loosestrife growing vigorously.

On most of the plots treated for the first time in 1960, all sprouting was absent by October 20 (Table 1, part F). On the plot treated with amitrole one plant had produced a single new sprout, and on the one treated with silvex in oil and water emulsion three plants had produced two, two and three sprouts, respectively. There was only moderate control of sprouting on the plot treated with the isooctyl ester of 2,4-D in water and on the one treated with ammonium sulfamate in water. On June 29, 1961 the plot treated with 2,4,5-T in oil and water emulsion showed complete control with no sprouts or seedlings. Silvex in water and the propylene glycol butyl ether esters of 2,4-D gave fairly good control. The results of treatment with the mixture of 2,4-D and 2,4,5-T in oil and water emulsion were inconsistent with previous results. Observations in October 1960 on this plot had shown no signs of regrowth; yet in June 1961 there were three large clumps of loosestrife growing vigorously and six scattered stems sprouting from the base. Formulations of 2,4-D also gave similarly inconsistent results.

Treatments in 1961

Table 1, part G shows the ratings for the plots, first treated in 1960 and re-treated in 1961, as recorded on August 31, 1961. There were sprouts growing in every plot, including the one treated with 2,4,5-T in oil and water emulsion on which there had been no sign of regrowth on June 29 before re-treatment. Observations on July 12, 1962 showed fair control of the loosestrife by 2,4,5-T in oil and water emulsion and by the mixtures of 2,4-D and 2,4,5-T in water and in oil and water emulsion. The isooctyl ester of 2,4-D, amitrole, ammonium sulfamate and the amitrole-ammonium sulfamate mixture gave almost no control, while the dimethylamine salt formulations of 2,4-D were only slightly more effective. Because of the prolonged dry weather, the entire marsh area was nearly dry. A dense growth of smartweed (*Polygonum*) was everywhere, indicating that repeated applications of herbicides had not sterilized the soil.

Table 1, part H shows the degree of control obtained in treating quarter-acre plots of loosestrife on June 29 and August 31, 1961. Fenuron pellets, spread among the loosestrife plants in water from the water's edge to a depth of 1 foot, had had little effect on the loosestrife probably because of the great dispersal of the fenuron by the water. The mixtures of 2,4-D and 2,4,5-T resulted in a fair initial kill of the tops of the plants, but these grew vigorously again in 1962. The mixture of silvex and atrazine apparently killed the mature loose-

strife plants, but a few seedlings appeared where the shore line was exposed.

DISCUSSION

The results of treating purple loosestrife in small plots with various herbicides were quite variable, and in no case did any one year's treatment result in complete destruction of all the loosestrife plants in the plot as evidenced by the resprouting in the following growing season. Consistently better results were obtained by making heavy applications (200 gallons per acre vs. 50 gallons per acre) when the concentration of herbicide in the solution remained constant. Differences between water solutions and oil and water emulsions of the herbicides were not constant.

Solutions of silvex and of mixtures of 2,4-D and 2,4,5-T generally provided the greatest degree of control. The oil and water emulsion of 2,4,5-T applied in the summer of 1960 seemed to give complete control as late as the end of June in 1961, but after that date sprouts appeared from the bases of several plants which were not completely destroyed even by a second application of the herbicide.

Because the storage pond or marsh was used each year to maintain the levels of ponds for waterfowl, there was an annual drawdown of water, plus loss by evaporation, so that conditions were similar in most respects to those that would prevail in small marshes when drawn down deliberately to aerate the marsh soils. What was not duplicated was the continuous flooding of a marsh, following drawdown, for a period of 3 to 5 years or more.

Attempts to control purple loosestrife with ammonium sulfamate were not successful, in contrast to the experience of Smith (1959). In no case was there more than a 50-per cent kill of the tops of the plants. Regrowth in the next season was always vigorous so that by flowering time plants were of normal size. Important differences in treatment may have been the use of a power sprayer on the Montezuma area where the impoundments were reflooded and not drawn down again after control of the losoestrife had been obtained. The storage pond at Howland Island was refilled naturally each winter and spring, but it was gradually drawn down each summer.

All observers have commented on the rapid invasion of wet areas by seedlings of purple loosestrife. The great abundance of loosestrife wherever it has become established provides an abundant supply of seed for such invasions. Control operations would have to be repeated each time a marsh is drawn down.

Purple loosestrife has some value as shelter and escape cover for pheasants and cottontail rabbits, so that its presence where cover would otherwise be lacking may be considered to compensate in small part, at least, for its aggressive nature where it is not wanted.

CONCLUSIONS

Purple loosestrife was controlled, but not eradicated, by foliar applications of water solutions or oil and water emulsions of the so-called low-volatility esters of 2,4,5-T or of 2,4-D and 2,4,5-T in mixture, or silvex, at a concentration of 8 pounds acid equivalent per acre when at least 200 gallons of total solution were applied per acre. Satisfactory control did not result from treatment with various amine salts of 2,4-D, the isooctyl ester of 2,4-D, a formulation of 2,3,6-TBA, amitrole or ammonium sulfamate. It was found necessary to repeat treatments to control resprouting and seedling growth in subsequent seasons.

To control loosestrife in small marshes that are drawn down in areas where it is present, it would be necessary to treat the marsh margins and bottom to kill the seedlings as they appear as well as the mature plants. When the marsh is reflooded, further treatment would be required to control scattered plants that resprout, or they might be removed by hand pulling. Purple loosestrife plants on pond margins and in nearby areas would need to be treated, so far as is possible, to reduce the sources of seed.

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A REVIEW OF VARIATIONS FOUND IN FISH SERUM PROTEINS[1]

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ABSTRACT

Use of the species-specificity of electrophoretic patterns of serum proteins in understanding phylogenetic relationships requires a knowledge of the manner in which these proteins may vary. The major studies that have been made of the conditions that cause serum proteins to vary in fishes are reviewed. Possible applications of such information in fish management and pollution research are suggested.

It has been known for more than 60 years that certain proteins characterize every species of plant and animal and that phylogenetic relationships are reflected in protein structure. The first application of this fact to taxonomic studies was by Nuttal (1901, 1904) who used the precipitin reaction in immune sera to test degrees of relationship in over 500 species of animals.

The protein components of animal blood serum are responsible for transporting the red cells, supplying all the materials for the body's metabolic requirements, defending against invasion and injury, maintaining body pH and osmotic pressure, and regulating cellular activity and function. These functions of the blood serum are common to all animals, and thus certain physiological features of the various blood serum protein molecules are retained in each species even when molecular changes may occur from species to species.

There is much evidence that these proteins vary among members of populations of fishes and other animals. Before the serum proteins in fish can be used for phylogenetic studies, a knowledge of the manner in which they may vary is needed. The purposes of this paper are to review the major studies that have been made of the conditions that cause serum proteins to vary in fishes and to suggest practical applications of such information in fish management and pollution research.

HISTORY

Nuttal (1904) did the initial work in a field now known as comparative or systematic serology. The basis for his work involved the precipitin reaction whereby the proteins in the serum of one animal are compared with those in the serum of another animal. The degree

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of serological correspondence, measured by the amount of precipitation of antibodies and antigens in the reaction, is thought to reflect the degree of relationship between the animals. The precipitin reaction occurs when the serum from each of two animals is allowed to react with rabbit antiserum against the proteins in the serum of one of the animals.

Immunological methods make use of a biological system to distinguish among protein relationships which are based upon differences in molecular orientation. This is in contrast to comparing proteins by electrophoresis where differences in charge, size and shape of the molecules are the basis for evaluation.

The early workers studying fish blood made direct quantitative chemical studies of its protein components and made some comparisons of various fishes. Vars (1934), Roche *et al.* (1940), and Field *et al.* (1943) did quantitative studies of the components of the blood of various species of fish. Recently, Phillips *et al.* (1957), Phillips (1958), and Shell (1961) did similar quantitative studies of fish blood.

Hall *et al.* (1926) found that the total nitrogen concentration in the blood of menhaden (*Brevoortia tyrannus*) increased with time when the fish were placed under asphyxiating conditions. They later stated that this was not a true increase since the total water in the blood decreased and thus tended to concentrate the protein components. Lepkovsky (1929), however, found that menhaden under no stress had varying concentrations of total nitrogen in the blood plasma. The albumin-globulin ratio (A/G) varied from 1.28 to 2.08 in those he examined.

Fontaine and Boucher-Firley (1932), in their comparison of fresh-water and salt-water species of fish, found a range of 25 to 70 grams per liter for the total serum proteins, with large individual variations. Demenier (1934) found variability within and among species in his determination of albumin and globulin concentrations, and his work on the European eel (*Anguilla vulgaris*) showed seasonal variation. Pora (1936) found concentrations of blood proteins to be higher in females than in males of a species of cat shark, but he reported opposite results for a species of skate. He suggested that the apparent sexual differences were due to endocrine influence. Adrianow (1937) showed that the A/G ratio did not change over a period of time in some fishes, but that it did change in the Crucian carp (*Carassius carassius*). Brachet (1940) in a histochemical study of proteins during the embryonal development of some fish, found considerable change in the concentration and appearance of different serum protein fractions during ontogeny.

It was not until Tiselius (1937) introduced a quick means of

separating proteins by the moving-boundary electrophoretic method that effective comparative studies of serum proteins could be made. Deutsch and Goodloe (1945) were the first authors to report species-specificity for electrophoretic patterns of plasma proteins using the Tiselius method. They separated plasma proteins of various animals and found large variations in the distribution of blood proteins among animals. The variations appeared in the form of different mobilities of protein components in an electric field and in the number and relative proportions of the components which did separate in the serum samples. In a later electrophoretic study of the blood serum proteins of some lower animals, Deutsch and McShan (1949) found that species-specificity also existed for electrophoretic protein patterns among these animals. Moore (1945), during the same period, found characteristic species differences in the electrophoretic patterns of serum proteins, obtained under comparable conditions, for certain mammals, birds and fishes. The patterns for each species were reproducible, and the differences with respect to quantity and presence or absence of components were significant between species.

SPECIES-SPECIFICY AND HEREDITY OF SERUM PROTEINS

After 1945, studies were published that substantiated the species-specific nature of the electrophoretic patterns of serum proteins for many species of fishes and other animals. (By this time, different electrophoretic methods were in use involving paper, gels and starch as media for separating serum proteins.) Some of these studies and the animals involved were as follows: Irisawa and Irisawa (1952), sharks; Brandt *et al.* (1952), birds and their hybrids; Drilhon (1953) eels and carp; Dessauer and Fox (1956, 1958), amphibians and reptiles; Zweig and Crenshaw (1957), *Pseudemys* turtles; Starr and Fosberg (1957), sharks; Woods and Engle (1957), marine invertebrates and fishes; Planas and Gras (1957), fishes; Saito (1957a), fishes; Woods *et al.* (1958), invertebrates; Engle *et al.* (1958), marine fishes; Drilhon (1959), teleosts; Chandrasekhar (1959), cyprinids; Drilhon (1960), teleosts, cyclostomes and selachians; Delcourt (1961), amphibians, reptiles and fishes; Das (1961), Indian carp; Gunter *et al.* (1961), elasmobranchs and teleosts.

The one point lacking in these papers was whether the species-specific proteins followed a pattern of Mendelian inheritance and thus could be reliably used for the study of phylogenetic relationships. To date, this point has not been completely resolved. Irwin and Cumley (1940, 1942) by immunogenetic techniques showed conclusively that, in pigeon crosses, species-specificity of certain serum proteins fell within the pattern of Mendelian inheritance. They anticipated that all species-specific relationships would be found to be gene-determined.

Pauling *et al.* (1949) showed that there was a difference in electrophoretic mobilities between normal human hemoglobins and those affected by sickle-cell anaemia. Ingram (1957) confirmed this and proved that these differences were under gene influence. The hormone, insulin, was found, in five species of mammals, to differ structurally in only one portion of the molecule (Sanger and Tuppy, 1951; Brown, Sanger and Kitai, 1955). Smithes (1959) determined that beta-globulin fractions C and D, in humans, were genetically controlled by a pair of autosomal alleles with no dominance. These cases of gene control on protein structure prompted Crick (1958) to suggest that a new field was being developed, which he called protein taxonomy, where the amino acid sequences of the proteins of an organism and the comparison of them between species would be studied.

VARIATION IN SERUM PROTEINS UNDER VARIOUS PHYSIOLOGICAL INFLUENCES

Drilhon (1954) found concentrations and mobility differences between the sexes in paper electrophoretic patterns of carp. Concentrations of serum total proteins differed (Bailey, 1957) between male, non-breeding female and breeding female goldfish after injection of estrodiol. Injection of sockeye salmon with estradiol monobenzoate (Ho and Vanstrone, 1961) caused differences between male and female serum protein levels. Serum vitellin was absent from the plasma of male, immature female, and spent female coho salmon (Vanstone and Ho, 1961). These authors found a lipoprotein (possibly vitellin) in the electrophoretic pattern that was associated with egg formation. Pacific salmon (Robertson *et al.*, 1961) were found to have sexual differences in total protein, albumin and globulin concentrations while moving from the sea to their spawning sites. In an electrophoretic study on serum proteins, Lecal (1958) placed fish of both sexes in different concentrations of salt water for various periods of time and found that the proportions of components changed and that the changes were different for each sex. Electrophoretic examination of the blood of 39 sturgeons showed low A/G ratios for smaller individuals (Magnin, 1960). Magnin indicated that these differences may have been associated with sexual maturity. Drilhon (1954) found differences in electrophoretic patterns of the serum protein concentration of carp by sex and degree of maturity. Mature and immature stages of elasmobranchs (Saito, 1957d) showed differences in the concentration of serum total proteins, and electrophoretic analysis showed that immature forms lacked some components that were present in mature forms.

Pacific salmon (Robertson *et al.*, 1961) that underwent starvation

for a longer period of time during migration, had decreased concentrations of plasma total proteins, globulins, and albumins. Drilhon *et al.* (1956) found quantitative differences in albumins and beta-globulins when starved trout were compared with well fed trout. Carp, during hibernation and prolonged fasting, showed a decrease in concentration for serum total proteins, albumins, and beta-globulins (Sorvachev, 1957).

Deutsch and McShan (1949) indicated that in fishes and other animals electrophoretic patterns would show serum protein fluctuations due to pathologies. Phillips *et al.* (1957) found that the A/G ratio in brown trout affected with kidney disease was the reverse of the value obtained from brown trout not affected by this disease. They suggested that examination of serum proteins in hatchery-reared fish may be an important aid for predicting outbreaks of disease in these fish. Flemming (1958) found that serum total protein varied in concentration in blood serum from diseased carp. Sindermann and Mairs (1958) showed that sea herring suffering from acute fungus disease had a sharp reduction in concentration of the albumin fraction of their blood serum. Hyperimmunized progeny of carp had a drastic reduction in total albumin concentration and to a lesser degree in alpha- and beta-globulins but a sharp rise in gamma globulins (Sorvachev *et al.*, 1962).

Moore (1945) reported evidence of major changes in serum protein fractions of fishes and other animals as age and development progressed. In a study of the plasma proteins of coho salmon Vanstone and Ho (1961) found that one protein fraction increased with age, while in smolt transformation another protein fraction disappeared. Booke (1962) found an increase with age in two serum globulin components in a population of whitefish (*Coregonus clupeaformis*). Sano (1960b) has shown that levels of alpha- and beta-globulins increased gradually with growth among rainbow trout fingerlings. There was also a great fluctuation of these constituents in the adult fish in his study and, in the females, the beta-globulin component reached a maximum with the development of the ovary in September.

Deutsch and McShan (1949) noted that, in general, differences in electrophoretic serum patterns were greater between species of fish than between any two individuals of one species. Sindermann and Mairs (1961), however, found marked individual variations in the concentration of serum total proteins in both pre-and post-spawning alewives. They found no major changes in paper electrophoretic patterns for alewives due to reproduction or freshwater migration. A study of plasma proteins in sturgeon (Magnin, 1958) showed wide individual variations in concentrations, especially in the albumin fraction.

Bendett *et al.* (1941) found that a dilution of blood serum occurs in migrating Atlantic salmon. This would account for a decrease in concentration of serum total proteins which these authors did not mention in their study. Robertson *et al.* (1961), however, found definite concentration changes in albumin and globulin fractions of migrating Pacific salmon. Drilhon *et al.* (1958) found that during the freshwater migration of two species of trout, there was no effect on the electrophoretic patterns of serum proteins.

Fish placed under different osmotic pressures showed altered concentrations of serum total protein, albumin, and globulin (Cordier and Barnoud, 1959).

Meisner and Hickman (1962) were able to show alterations in the A/G ratio of rainbow trout placed under two temperatures and no sign of effect on the serum total protein pattern due to exposure to two different photoperiods.

Seasonal variations (Saito, 1957c) in concentrations of total serum protein and albumin were found in mackerel and carp. Flemming (1958) noted that the A/G ratios varied in overwintered carp. Sano (1960a) found a seasonal variation of total serum proteins in rainbow trout.

Electrophoretic patterns of serum protein in fishes, exposed to polluted waters and waters with various concentrations of chemical agents, showed concentration shifts in the various components making up the pattern (Fujiya, 1961).

OTHER PROTEIN SYSTEMS AND ELECTROPHORETIC METHODS FOR DETECTING PHYLOGENETIC RELATIONSHIPS

Bier (1959), Wolstenholme and Millar (1956), and Block *et al.* (1958) have discussed the theory and general methods of different electrophoretic techniques. Grabar and Williams (1955) have described an immuno-electrophoretic method for separating antigenic substances through the combination of techniques used in serology and electrophoresis. Each constituent of the protein mixture studied gave independent specific precipitin bands which could be distinguished owing to their immunological specificity and which were defined by their relative electrophoretic mobility. However, no means of making quantitative measurements has been applied to this method. Bargetzi (1958) separated two forms of whitefish by using this method on the basis of patterns of different antigens.

Hashimoto and Matsuura (1958–59) discovered multiple hemoglobins in five species of fish by electrophoretic analysis. Connell (1953), using the Tiselius method of electrophoresis on extracts of fish muscle protein, found differences in the patterns such that he could separate the different species of fish.

APPLICATIONS TO FISH MANAGEMENT AND POLLUTION RESEARCH

For some aspects of fish management, precise identification of a species, a group or a race is required. If electrophoretic patterns of fish serum proteins are used along with traditional morphometric measurements, such identification may be less difficult. For example, if a lake contains several related species of fish, or sub-populations of a species that exhibit different growth rates, as can be found in Lake Superior (Edsall, 1960), electrophoretic patterns of their serum proteins can aid in separating morphometrically similar forms.

It has been found (Fujiya, 1961) by electrophoretic techniques that the serums of fish exposed to certain concentrations of pollutant materials, such as inorganic chemicals and pulp mill waste, are different from the serums of unexposed fish. Fujiya also indicated that this was true even when concentrations were below those necessary to cause any outward sign of distress. Thus the technique might be used to determine the minimum levels of various pollutants in streams and other waters that will alter the serum protein patterns of fish and have a detrimental effect upon them. Correlated with such data an electrophoretic determination of the serum proteins of dying fish might constitute legal evidence in suspect pollution cases.

DISCUSSION AND CONCLUSIONS

The blood tissue is perhaps more dependent on the physiological state of an organism as a whole, than is any other tissue. The author has cited studies showing that sex, spawning, food, osmotic pressure, disease, temperature, light, age, hibernation, hormones, oxygen depletion and season have some effect on the total serum protein complement of fish. All of these factors are interrelated in some degree, and no one is independent in its action. There is a close correlation between the blood, the protein system and the physiological state of a fish. Much of the variation in its serum proteins, caused by different conditions, places a stress on the fish to which it reacts, each time, in the same manner. An increase in the concentration of globulin is accompanied by a decrease in that of albumin. If electrophoretic patterns of the blood serum proteins of fish are to be used for phylogenetic, management, and pollution studies, the variables causing changes in these patterns must be recognized. Concentrations of serum proteins may change, but this will not affect the molecular structure or species-specific nature of these proteins.

Gross changes in electrophoretic patterns are the result of changes in the concentrations of protein components or the addition or subtraction of a component. Many of the papers reviewed in this study have stated that a system of standard conditions is required to pro-

vide for comparison of protein patterns among animals. Saito (1957b) showed that re-use of buffers can change electrophoretic patterns, and Kohn (1958) found that large quantities of serum protein can mask minor components in electrophoretic separations. The electrophoretic method which allows for careful characterization of each curve with respect to shape, symmetry and width of each protein peak, as well as for the tendency of adjacent peaks to separate from or approach each other, will provide the best basis for comparing the serum proteins of fishes.

Serum protein patterns should be carefully described under the categories of mobility together with specified conditions as to buffer ions, ionic strength, pH, and protein concentration. To obtain reliable quantitative electrophoretic measurements of fish sera, the number of fish sampled must be large, they must be healthy, and they must be separated by age and sex.

The biological concept of individual, species and genus reflects different orders of organization which are manifested by morphological features. It is not unlikely that, within the complexity of the protein molecule, similar levels of organization exist. If this is found to be true, the biologist will be called upon to work with the biochemist to elaborate the species concept.

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USE OF THE EYE LENS AS AN INDICATOR OF AGE IN THE RED FOX[1]

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ABSTRACT

Tabulation of the dried weights of eye lenses from 72 known-age silver foxes demonstrated that lens weight increased with age and that the distribution of the data served to separate juveniles from adults with approximately 92 per cent accuracy. Similar data for 458 wild red foxes also showed that juveniles could be separated from adults with a high degree of accuracy. For the red foxes, the separation fell between 203 and 213 milligrams. For 78 specimens the distribution of juveniles and adults according to lens weight was compared with that according to the degree of ossification of the proximal epiphysis of the humerus: there was complete agreement.

The dried weight of the eye lens as an indicator of age has been described for several species of game mammals: cottontail rabbit (*Sylvilagus floridanus*) by Lord (1959); gray fox (*Urocyon cinereoargenteus*) by Lord (1961); raccoon (*Procyon lotor*) by Sanderson (1961); fox squirrel (*Sciurus niger*) by Beale (1962); pronghorn antelope (*Antilocarps americana*) by Kolenosky and Miller (1962); and white-tailed deer (*Odocoileus virginianus*) by Lord (1962). This paper presents data on the use of this technique for judging the age of red foxes (*Vulpes fulva*) from New York State.

MATERIALS AND METHODS

Eye lenses from known-age wild red foxes were not available. However, the silver fox, which is a color phase of the same species, is raised commercially on fur farms and these afforded a source of material. Eye lenses from 72 known-age silver foxes were obtained. All were collected immediately after death from foxes pelted during late December.

Comparative material from 458 wild red foxes was obtained chiefly from State and county trappers working on the wildlife rabies control program. They were supplied bottles containing 10 per cent formalin and instructed to collect eyes from red foxes trapped during specific periods. The eyes were removed at the trap site immediately after the fox was killed. In 1960 and 1961 eyes from 367 specimens were collected during September and October when foxes were

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[1] A contribution of Federal Aid in Fish and Wildlife Restoration Project W-35-R. The authors wish to acknowledge the assistance of the trappers on the wildlife rabies control program in collecting wild specimens, of the Bennett Fur Farm (Victor, N. Y.) in supplying silver fox specimens, and of Miss Susan Bates in weighing lenses and tabulating data.

approximately 6 months, 1½ years, 2½ years, etc. of age. In 1962 eyes from 91 specimens were collected during April and May when adult foxes were approximately 1 year, 2 years, etc. of age.[2] In addition, lenses were obtained from four animals captured as pups and raised in captivity before being sacrificed at desired time intervals. During 1961 the humerus from one leg was also collected from 78 of the specimens trapped and assigned the same field number as the lens from the same animal.

All eyes were preserved in 10 per cent formalin. The lenses were washed in tap water after being separated from the eyes, rolled in paper toweling to remove excess moisture, and placed in uncapped shell vials in a drying oven. Drying time was 48 hours at 80° C. Weighing was done on a Mettler model B, single-pan, direct-reading balance. When both lenses from a single animal were available, both were weighed and the mean plotted.

FINDINGS

The dried weights of the eye lenses from the 72 known-age silver foxes are plotted against age in months in Figure 1. Since only the year of birth was available, the foxes were presumed to have been born during April. These data indicate clearly that lens weight increased with age. Also, as age increased, the range of lens weights from individuals of similar age increased. Lord (1961) noted this characteristic in the gray fox. Overlapping of lens weights between individuals of different ages is noticeable, but is least evident between foxes 9 months old and those 21 months of age. The lens weights for this sample of captive silver foxes serve to separate those less than 1 year old from those more than a year in age with approximately 92 per cent accuracy.[3]

The frequency-distribution of lens weights for 367 red foxes trapped during September and October is presented in Figure 2. A well defined break of some 10 milligrams is apparent in the range of 203 to 213 milligrams; one record was an exception. This break is considered to separate juveniles from adults. Similarly well defined breaks are lacking, however, in the distribution of the adult specimens. This lack of clear definition between age groups among adults is

[2] In central New York breeding occurs chiefly from mid-January to late February (Sheldon, 1949; Layne and McKeon, 1956), the gestation period is about 51 days (Seton, 1929; Hamilton, 1943), and the great majority of the pups are born from about the second week of March through the first week of April.

[3] Lens weights of known-age silver foxes, as plotted in Figure 1, which are widely separated from the main grouping for an age group may in part have been a result of error by fur farm personnel. Foxes at the farm are not tagged, and occasionally in moving animals from pen to pen the individual identity and age of an animal is lost.

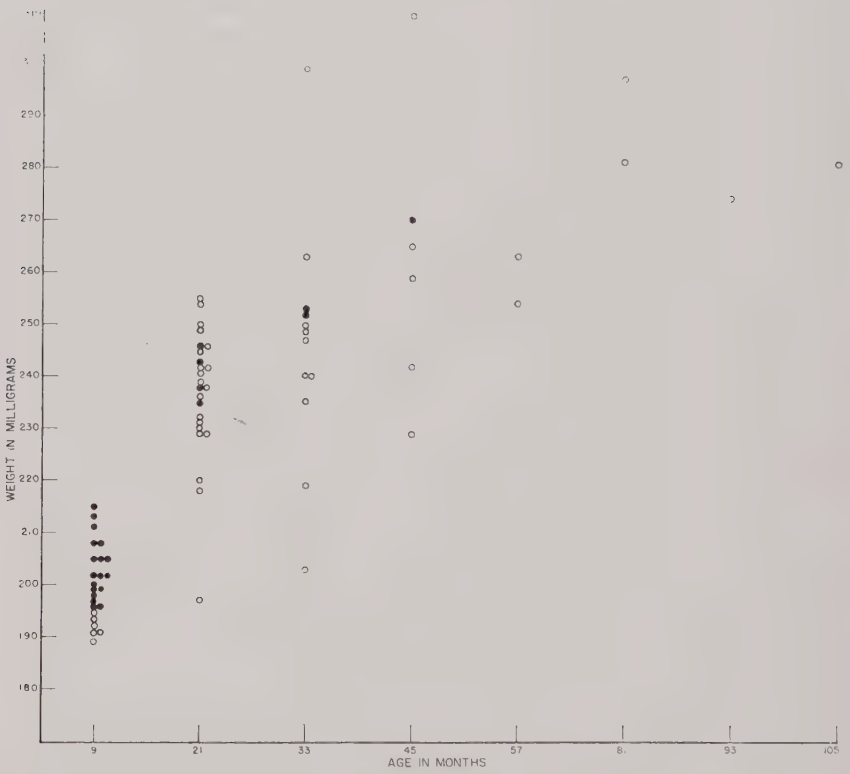

Figure 1. Distribution, according to age, of dried weights of eye lenses from 72 known-age silver foxes. (symbols: solid = male; open = female)

further shown by the distribution of lenses collected during April and May (Figure 3).

The ages of 78 red foxes trapped in Erie County during September and October were judged according to the degree of ossification of the proximal epiphysis of the humerus as described by Reilly and Curren (1961). They were found to be in complete agreement with those determined by eye lens weights (Table 1). Age determination by the lens method was based on 210 milligrams as the point of separation between juveniles and adults.

Variation between lenses from the same animal was found to be insignificant. The average variation for 155 specimens was 3.7 milligrams or 1.7 per cent (Table 2).

The mean lens weights recorded for female silver foxes were lighter than those for males (Table 3). This may have been related to the small size of the sample. But, in the data for wild red foxes (Table 4), the lens weights in both juvenile and adult categories were significantly lower than those for males ($P = .05$). However,

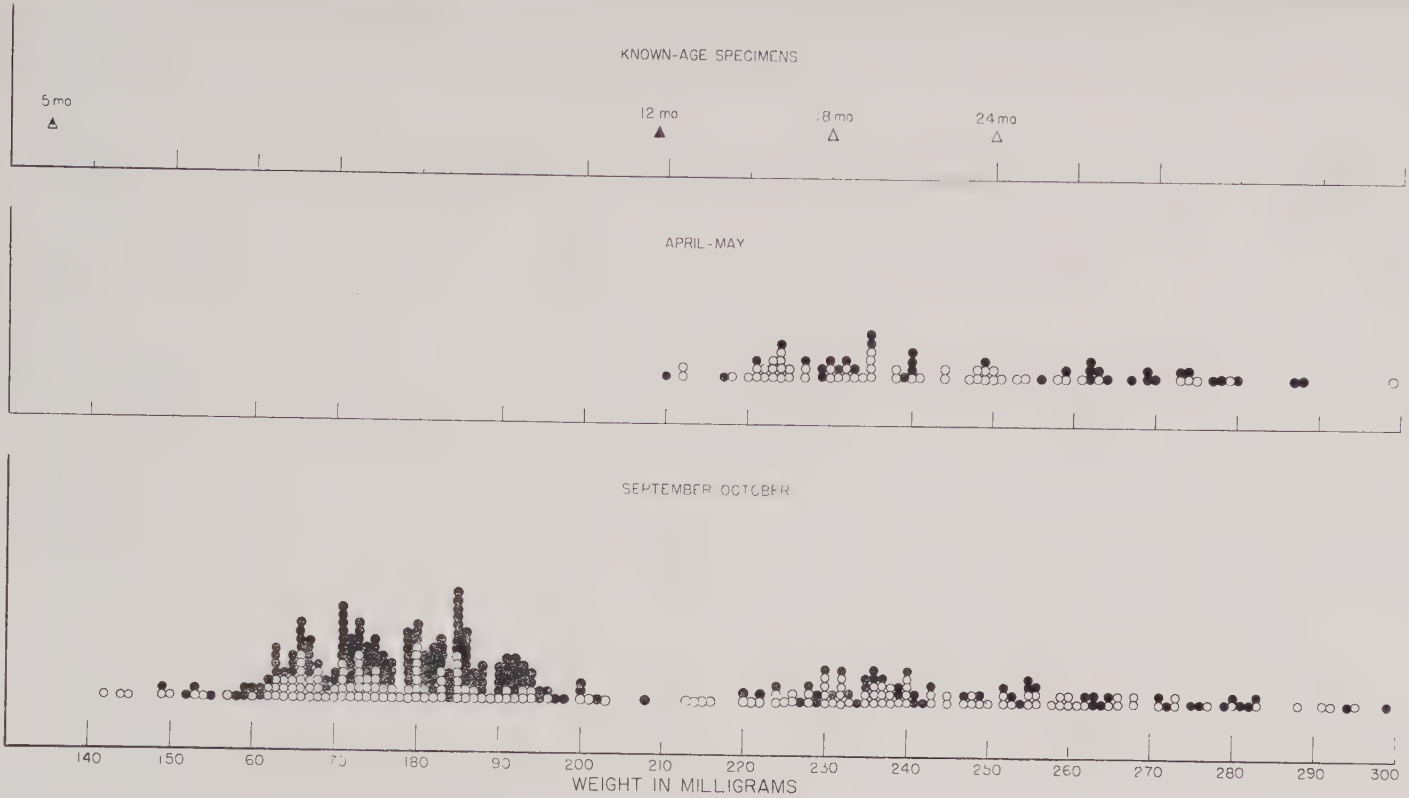

Figure 2. Distribution of dried weights of eye lenses from 367 wild red foxes trapped during September and October, 91 trapped during April and May, and four captive known-age specimens. (symbols: solid = male; open = female; divided = sex unknown)

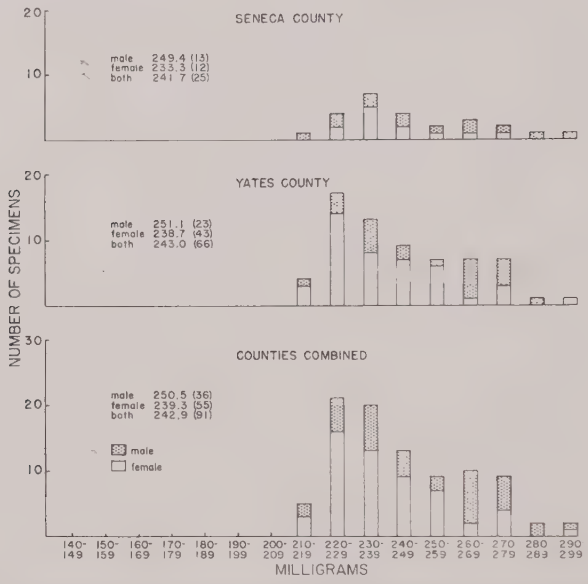

Figure 3. Distribution, for each county, of dried weights of eye lenses from adult wild red foxes trapped during April and May, including mean weights and numbers of specimens according to sex.

for the purpose of determining age ratios for population analysis this difference is not great enough to warrant tabulating the records by sex.

For adult males, the mean lens weights of specimens taken in April and May were as heavy as those for animals taken in September and October. For adult females, on the other hand, they were significantly lighter for April and May specimens than for those taken in September and October. The reason for this is unknown.

Table 1. Age Distribution of 78 Red Foxes According to Two Age Criteria

Criterion	Juvenile		Adult	
	Male	Female	Male	Female
Epiphysis of humerus.	35	27	9	7
Eye lens weight *				
Number.....	35	27	9	7
Mean weight.....	179.3	172.0	254.4	245.4
Standard deviation.	12.6	12.8	20.9	20.6
Range.....	148.8–207.7	144.6–193.4	224.4–283.1	213.2–272.0

* In milligrams.

TABLE 2. VARIATION IN WEIGHT BETWEEN THE EYE LENSES OF INDIVIDUAL RED FOXES

Source	Number of foxes	Mean lens weight in milligrams	Mean variation between individuals	
			Milligrams	Per cent
Erie County	74	190.5	2.8	1.5
Seneca County	19	251.5	3.4	1.4
Yates County	58	243.1	5.0	2.1
Captive	4	197.9	1.3	0.7
Total	155	217.9	3.7	1.7

TABLE 3. DIFFERENCES BETWEEN THE SEXES WITH RESPECT TO EYE LENS WEIGHT FOR 72 KNOWN-AGE SILVER FOXES

Age in months	Number	Sex	Weight in milligrams		
			Mean	Difference *	Range
9	18	male	203.3		195.5–215.2
	6	female	192.0	−11.3	188.6–194.8
	24	both	200.5		188.6–215.2
21	4	male	240.4		234.7–245.6
	20	female	236.2	− 4.2	197.3–255.2
	24	both	236.9		197.3–255.2
33	2	male	252.3		252.0–252.6
	10	female	244.4	− 7.7	203.5–298.8
	12	both	245.7		203.5–298.8
45	1	male	269.5		..
	5	female	260.8	− 8.7	229.1–308.8
	6	both	262.3		229.1–308.8
57	2	female	258.4	..	178.5–262.9
81	2	female	289.1	..	280.8–296.6
93	1	female	274.3	..	.
105	1	female	280.8	..	..

* Mean weight of females compared with that of males.

The frequency distributions of lens weights presented in Figure 4 are of interest. Plotted by county, the data for adults (weighing approximately 210 to 300 milligrams) appear to exhibit a bimodal frequency, which may reflect variations in the proportions of different age groups in the population. However, the locations of the modes vary slightly for lenses from counties in different geographical regions of the State, and, when all lens weights for the four counties are com-

Table 4. Differences Between the Sexes with Respect to Eye Lens Weight for 458 Wild-trapped Foxes

Period trapped	Number	Sex	Weight in milligrams		
			Mean	Difference *	Range
Juvenile					
September-October	141	male	178.5		148.8-207.7
	101	female	174.7	− 3.8	144.6–202.6
Adult					
September-October	48	male	250.7		220.3–298.7
	77	female	246.1	− 4.6	213.2–294.6
April-May	36	male	250.6		209.2–287.7
	55	female	239.3	−11.3	211.9–298.6
September-May	84	male	250.6		209.2–298.7
	132	female	243.3	− 7.3	211.9–298.6

* Mean weight of females compared with that of males.

bined, the bimodal pattern is obscured. Such modal variations may be a result of nutritional differences as suggested by Lord (1962). Larger samples would be needed to show whether variations of this kind were statistically significant. Lens weights from known-age wild foxes would also help to substantiate these observations. The few such lenses obtained during this study were from animals which did not thrive in captivity and were of small size.

DISCUSSION

The distribution of eye lens weights for wild red foxes exhibited a well defined break comparable to that which was found to separate juvenile from adult specimens in the sample of known-age silver foxes. Exceptions were few. It is concluded that juveniles can be separated from adults by this technique with a high degree of accuracy, but the separation of age groups among adults appears remote. Larger samples of adult animals would be needed to clarify this point. The use of other techniques, such as those of Churcher (1960) and Wood (1958), in combination with eye lens weights might afford a means of approximating the age of adults.

Data from known-age captive silver foxes cannot be used to construct a lens-growth curve that will apply to wild red foxes. Farm-raised silver foxes are slightly larger than their wild counterparts. Average weights at 35 weeks of age were given at 12.5 pounds for

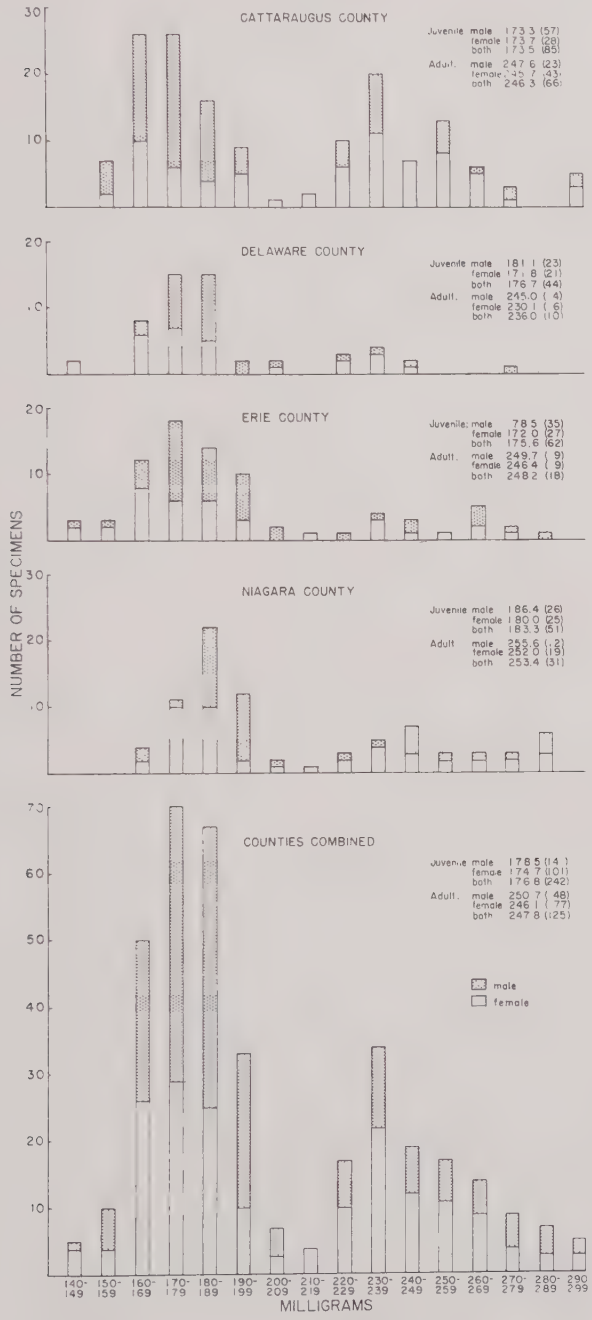

Figure 4. Distribution, for each county, of dried weights of eye lenses from wild red foxes trapped during September and October, including mean weights and numbers of specimens according to age and sex.

males and 10.4 pounds for females in a report of the National Research Council (1953). The report also stated that weights of mature males over 35 weeks of age range from 12 to over 15 pounds and that those of females of comparable age range from 9 to over 11 pounds. Linhart (1961) found the average weight of 20 male and 20 female red foxes trapped in New York during November and December to be 11.0 and 9.3 pounds, respectively. Nutritional differences between penned and wild animals are also a factor. Lord (1962) found that the growth rate of the lens was greater for cottontail rabbits raised in captivity than for wild, recaptured cottontails. He further stated that a number of pen-raised deer had heavier lenses than would be expected judging from the general trend of the growth curve of the lens for wild deer.

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GENERAL NOTES

FISHER VS. DEER

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Little is known of the degree to which the fisher (*Martes pennanti*) may prey upon deer (*Odocoileus*). Hamilton and Cook (1955) stated "we believe . . . that few deer, including fawns, are attacked by fishers". The popular theory among outdoorsmen who know both animals is that a large fisher can kill an adult deer. But the only recorded observations are those related by **Manly Hardy (Seton, 1929,** p. 475). He reported an instance in which a fisher that attacked a large buck was thrown from its back and badly hurt. But he also said that he knew of instances in which fisher had killed deer. The following observation is, therefore, of interest.

In 1957, about 2:00 p.m. in late May or early June, Robert Parker of Long Lake in Hamilton County (N. Y.) and some companions were repairing a road about 9 miles northwest of Long Lake. They heard a noise in the woods nearby, and Parker investigated. He saw a fisher "about the size of a small fox" biting and clawing the back and sides of a fawn which was "only a few days old". When Parker approached, the fisher ran off. The fawn was badly scratched on its back, sides and neck, and it died a few days later in the care of Conservation Officer James Hall. There seems little doubt that, if it had not been disturbed, the fisher would have killed this fawn.

On Parker's approach, the fisher first ran just a few feet and stopped on a stump. Parker had a shovel and tried to kill the animal, but it merely moved out of reach each time he swung. It then ran off.

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A SECOND ESTURINE RECORD FOR THE ROUGH SCAD (*TRACHURUS LATHAMI*)

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Mansueti (1960) published an account of esturine penetration made by the rough scad (*Trachurus lathami*). That record was based on a specimen collected off the mouth of the Potomac River during a trawl survey of Chesapeake Bay sponsored jointly by Maryland's Chesapeake Biological Laboratory and the Virginia Institute of Marine Science.

In August of 1959 the author, working for the New York State Conservation Department, collected a specimen of *Trachurus lathami* in a 300-foot, ¼-inch-mesh bag seine at Heckscher State Park on Great South Bay of Long Island. The salinity at this station was 18.1 ppt and the maximum water depth was 6 feet. This constitutes a second definite record from waters of low salinity and a shallow water record. Three other specimens of this species reported from the New York area were caught in waters of oceanic salinity (Nichols and Breder, 1927).

This fish measured 50 millimeters in total length, 43 millimeters in standard length and 45 millimeters in fork length. Other data were: anal fin rays II-I, 28; dorsal fin rays VIII-I, 30; and pectoral fin rays, 21. The specimen is now part of the fish collection at Cornell University.

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ACCEPTANCE BY WILD FOXES OF CERTAIN BAITS FOR ADMINISTERING ANTIFERTILITY AGENTS[1]

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ABSTRACT

Field tests of the acceptance by wild foxes and other species of certain baits for administering antifertility agents were conducted in central and eastern New York in 1961, 1962 and 1963. Of eight types of baits compared, no one type was preferred. Foxes, dogs and crows, in that order, most frequently consumed baits. Other wild and domestic species took baits only occasionally. Bait acceptance by foxes was poor early in the winter but increased substantially as the winter progressed. To the extent these results are representative, the distribution of antifertility agents early in the winter would be of little value, and substances that would be effective only when eaten by foxes prior to mid-January would be of little use.

Traps and poison are traditional tools for reducing animal abundance. Recent interest in antifertility agents that may be administered orally prompted investigations by Davis (1961), Balser (1964), Linhart (1963), and Linhart and Enders (1964) concerning their effectiveness in lowering the productivity of wildlife populations. It also seemed that this approach might have some use in controlling sylvatic rabies among foxes. Successful field application would be dependent, among other factors, on the consumption of treated baits by the target species. Although poison baits have been used for many years to control foxes and coyotes, no critical evaluation of species preference for different types of baits has been published. Therefore, field tests of the acceptance of various baits by foxes (*Vulpes fulva* and *Urocyon cinereoargenteus*) and other species were undertaken.

Correlation of the relative acceptance of the baits tried with their ease of manufacture, cost and means of distribution would indicate which held the most promise. Furthermore, seasonal variation in bait consumption by foxes would serve to orient laboratory studies of antifertility compounds; consistent failure to consume baits during a certain phase of the breeding season would mean that a control program at that time would be impractical. The frequency with which other animals take baits under differing field conditions would also be important because foxes would be the target species in New York and inhibition of reproduction in other species would not be desirable in most instances.

[1] The author wishes to thank Franz V. Winter, conservation aide, for making baits and for his many helpful suggestions. Trappers and supervisors on the State wildlife rabies control program conducted the field tests and contributed valuable advice.

[2] Present affiliation: U. S. Bureau of Sport Fisheries and Wildlife, Bldg. 45, Federal Center, Denver, Colorado.

PROCEDURE

Bait-evaluation studies were conducted during the winters of 1961, 1962 and 1963. Most were made during January and February, although several studies were begun in mid-December and continued until the disappearance of snow in mid-March. The work was done chiefly in central New York in Chemung, Cortland, Schuyler, Seneca, Tioga and Yates Counties, but limited observations were also made in Saratoga and Fulton Counties in eastern New York. Professional trappers assigned to the State wildlife rabies control program carried out all field tests under the direction of supervising wildlife trappers.

Bait stations were placed in fox crossings along secondary and rural roads in areas where reports or reconnaissance indicated moderate to high fox populations were present. Stations were established by throwing the required number and types of bait a few feet off the road onto the snow to avoid leaving human tracks at the station site. Stations were visited daily, weather permitting, and data were recorded as to which baits, if any, had been eaten, and, if so, how many. During most studies baits were replaced the day following consumption. Bait consumption was determined by the absence of baits and identification of animal tracks at the station. Stations snowed under or excessively tracked up were moved a few feet, or were relocated across the road, or were abandoned. When two or more species visited a station during the same night, making it impossible to determine which had consumed the baits, the data were not tabulated.

Tests of the degree of acceptance by foxes were conducted by providing each trapper with two different types of bait that were then placed at a series of bait stations in a standardized pattern. Both types were tried at each station by placing two groups, each having three baits of the same material, 10 to 20 feet apart. Equal opportunity was thus afforded for consumption of both types.

Eight different types of bait were compared (Table 1), the various trappers being assigned different combinations. In Tests A and B a stick or piece of bark dipped in a standard fox lure was thrown onto the snow, and the two groups of three baits each were then thrown 10 feet to either side of the lure. For Tests C through F each bait had inserted in it a chicken or crow flight feather the tip of which was dipped in a fox lure at the time baits were placed in the field. The method of bait manufacture and a tallow bait with feather inserted are shown in Figure 1. This type of bait was described by Ballantyne and O'Donoghue (1951). Although the use of a feather dipped in lure was not shown in these tests to be superior to merely placing lure adjacent to a bait, the procedure is simple and would seem likely to attract foxes more readily, particularly where baits were covered by snowfall.

TABLE 1. TYPES OF BAIT USED IN THE VARIOUS TESTS OF ACCEPTANCE BY FOXES

Test	Bait No.	Type of bait	Description
A	1	Limburger cheese	¾-inch cubes
	2	Beef fat	Fried and cut into 1-inch cubes
B	3	Crackling mixture	Cheese, fish, suet and bacon ground, fried and pressed into 1-inch balls
	4	Venison	Raw, 1-inch cubes
C	5*	Venison	Raw, 1-inch cubes
	6*	Rendered tallow	Rendered mutton, beef and pork tallow melted and poured into ½-ounce paper cups
D	7*	Rendered tallow and cheese	Limburger cheese paste smeared on tallow bait like No. 6
	8*	Rendered tallow	Same as No. 6
E	9*	Rendered tallow and "honey bait"	Small quantity of a commercial honey bait smeared on tallow bait like No. 6; honey bait consisted of unknown proportions of honey, Tonkin musk, beaver casters, muskrat anal glands, and spices
	10*	Rendered tallow	Same as No. 6
F	11*	Rendered tallow and honey bait mixture	16 quarts of rendered tallow, 2 quarts of honey, and ½ quart of unknown mixture of Tonkin musk, beaver casters, muskrat anal glands, and spices blended with Waring blender and poured into ½-ounce cups
	12*	Rendered tallow	Same as No. 6

* Each bait had inserted in it a chicken or crow flight feather the tip of which had been dipped in a fox lure.

During 1961 and 1962 several trappers noted that bait acceptance improved as the winter progressed. Since most of the studies up to that time had been of short duration, a test was carried out during the winter of 1963 to clarify these observations. An area of about 60 square miles was selected in southcentral New York. Fox populations were moderately high. Bait stations were established on December 10, after the first measurable snowfall, and maintained until March 10 when spring thaws terminated the study. Five tallow baits were placed at each station. Weather permitting, stations were checked daily and baits consumed were replaced the following day. Bait stations sometimes were moved to different locations when dis-

Figure 1. Equipment used in manufacturing baits, and a completed tallow bait.

turbance by dogs or a lack of fox visits resulted in few or no data. Daily snow depths were estimated by the trapper. Consumption of baits through the test period indicated seasonal variation.

Many animals breed later than the fox. The possibility of inhibiting reproduction in animals other than the target species, through consumption of baits intended for foxes, prompted limited field tests in 1961 to determine the persistence of tallow baits during late winter. Fifty bait stations were established along a rural road in Tioga County on February 21. Two tallow baits were placed at each station. Stations were checked on February 28 to determine the number of baits remaining.

In 1962, a second effort was made to determine the persistence of baits with the advent of spring and increased animal movement. On February 20, five tallow baits were placed at each of 64 stations in Yates County. Snow and adverse weather conditions made observations impossible until March 13, three weeks after the baits had been placed.

FINDINGS

Trappers established 1,762 bait stations during the winters of 1961, 1962 and 1963. Stations were checked daily for varying periods of time depending on weather conditions and objectives of the studies. Animal visits to these stations totaled 1,675, and on 1,138 of these occasions animals had eaten one or more of the baits.

Acceptance of Baits

Results of the acceptance tests are shown in Table 2. The data clearly indicate that no one bait was preferred. These findings are not surprising when the omnivorous habits of the fox are considered.

TABLE 2. DEGREE OF ACCEPTANCE BY FOXES OF BAITS TESTED

Test	Bait No.	Baits available for consumption	Baits consumed	
			Number	Per cent
A	1	120	99	83
	2	120	99	83
B	3	39	19	49
	4	39	19	49
C	5	57	53	93
	6	57	51	89
D	7	36	35	97
	8	36	33	92
E	9	108	79	73
	10	108	81	75
F	11	105	95	90
	12	105	87	83

Comparisons between tests were not possible, as most were conducted under different weather conditions and fox population densities.

Baits made of rendered tallow were the most suitable when convenience of handling, ease of manufacture, cost, and acceptance were all considered. This type seems more adaptable to the insertion of various drugs, or possibly dyes for marking animals which consume baits. Another advantage of tallow baits is that they will melt and become ineffective with the onset of warm weather.

The data were correlated to show the relative frequency with which various mammals and birds visited stations and consumed baits (Figure 2). Bait stations were located so as to obtain maximum fox visitation, and this species accounted for 45 per cent of all visits on which baits were consumed. Foxes frequently visited stations without eating the bait; this was the case on 41 per cent of the total fox visits (865) recorded. However, when the various trials in the different years are considered separately, this proportion varied from about 17 to 81 per cent.

Dogs, mostly from nearby farms, were the next most frequent species to visit bait stations, accounting for 30 per cent of all visits on which baits were consumed. In many instances they competed for baits intended for foxes, and trappers were frequently forced to move bait stations to new locations to avoid persistent consumption of baits by dogs.

Crows ranked third (16 per cent) and also provided competition

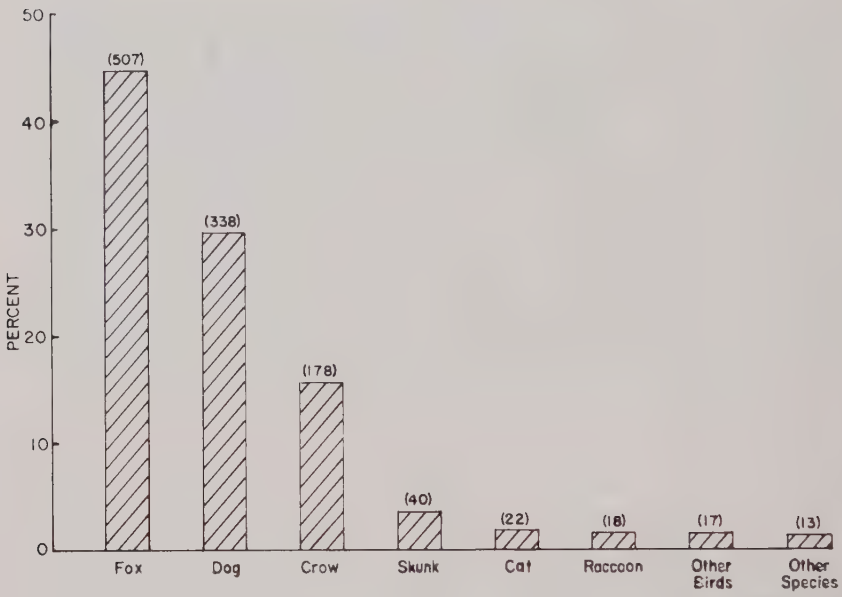

Figure 2. Distribution by species of animal visits to bait stations where baits were consumed on areas in central New York (figures in parentheses are numbers of visits).

for foxes. The problem was more localized than in the case of dogs, being particularly troublesome in the Finger Lakes region.

Skunks and raccoons accounted for only 5 per cent of all visits during which baits were consumed. In New York, raccoons, skunks and opossums seldom leave their dens in midwinter. Raccoon and skunk visits were not generally recorded until about mid-February, and most studies were terminated one or two weeks later with the disappearance of snow. To what extent these species would consume baits upon increased movement in early spring remains unknown. However, because of their limited home range, as compared with that of the fox, it seems unlikely that significant proportions of a population would be affected by treated baits.

Visits by cats and miscellaneous birds constituted only 3 per cent of those recorded and presented no problem. Other species accounted for the remaining 1 per cent. These included 12 visits by opossums and one by a weasel. Occasionally mice consumed some baits, but visits by rodents were not recorded in all cases.

Seasonal Variation in Bait Consumption

Results of the study in 1963 to determine seasonal variation in bait consumption by foxes are shown in Figure 3. The upper graph illustrates, by biweekly periods, the proportion, of the fox visits

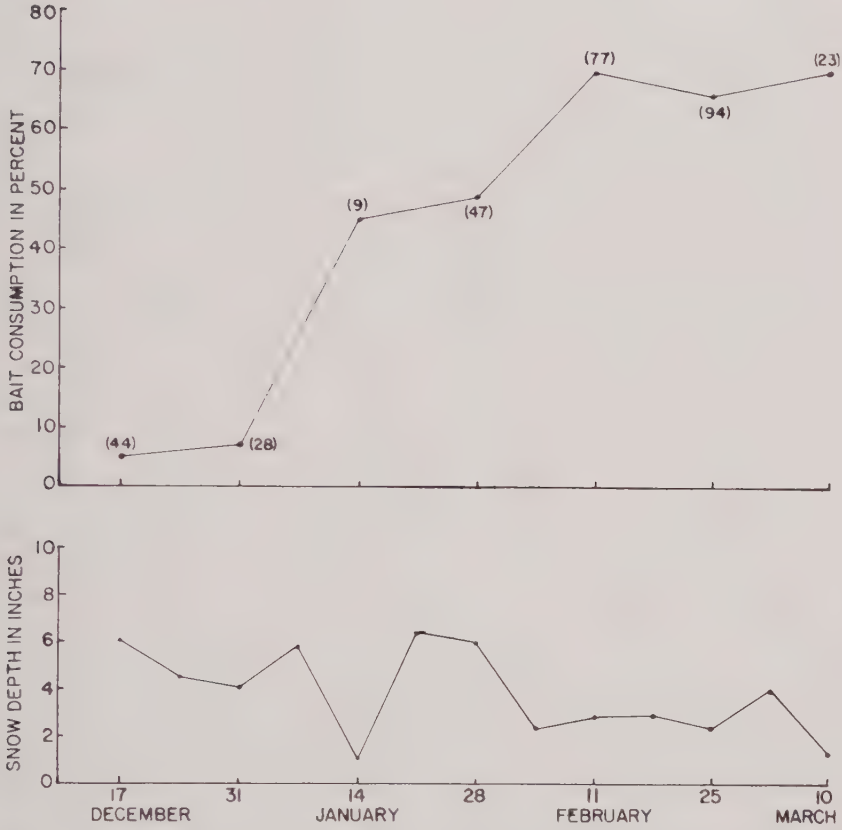

Figure 3. Seasonal variation in bait consumption by foxes as represented by the proportion of recorded visits to bait stations, on which baits were eaten, and trend in mean snow depth, on area in south-central New York during December-March period (figures in parentheses are numbers of visits from which percentages were derived).

recorded, on which one or more baits were eaten. During the early portion of the winter, the proportion was low, but it increased as the winter progressed, reaching nearly 50 per cent in late January and 70 per cent in mid-February. Snow depths, as estimated by the trapper, (lower graph) did not increase toward the latter part of the winter, and the mean weekly snow depth did not exceed 7 inches at any time. It seems likely that the increase in bait consumption was related to the availability of natural food which probably became less abundant as the winter progressed. Dead deer which remained in the field after the hunting season may, in part, have been the reason for low attractiveness of baits during early winter. When present, such deer constitute a major winter food for foxes.

Bait Persistence

Two tests were designed to measure the persistence of baits during late winter. The data indicated that the baits were either quickly consumed by animals or melted with the advent of warm weather. Only seven of the 100 baits put out in Tioga County on February 21, 1961 remained when checked 1 week later. However, a thaw had removed nearly all snow during the intervening week making it impossible to determine if baits had been melted by warm weather or had been eaten. When the 320 baits put out in Yates County on February 20, 1962 were checked 3 weeks later, 52 were still present.

DISCUSSION

Field tests demonstrated that no one of the baits tried was preferred by foxes. The results suggest that the possibility for finding a "super bait" is not promising. However, because of the importance of bait acceptance in the concept of controlling fox abundance by the use of antifertility agents, additional trials with other promising baits would probably be worthwhile.

Red foxes are approximately nine times as numerous as gray foxes in New York, although the ratio varies considerable in different localities. Field tests in 1961 and 1962 suggested that in some cases, especially early in the winter, gray foxes ate baits more readily than did red foxes. Not until 1963 were trappers instructed to note, when possible, which species had visited a bait station. The data obtained, although meagre, indicate that differences in bait acceptance sometimes occurred.

Dogs and crows were the only other species that took substantial proportions of the baits intended for foxes. Development of a bait which would repel dogs but be readily taken by foxes does not seem likely because of the close kinship between the two. A limited test with "dog repellents" tended to confirm this supposition. Kalmbach and Welch (1946) showed that coloring grain with certain dyes deterred birds from eating such grain but that rodents took it readily. Development of a colored bait which would repel crows but not foxes might be feasible. Consumption of baits by other wild or domestic species does not appear to be a significant problem.

The tests also revealed that foxes frequently visited bait stations but did not consume baits. Based on all the data recorded, foxes failed to consume baits on 41 per cent of their visits to stations, although this varied considerably in individual instances. However, frequency of consumption was very low generally until about mid-January. Although population density may have had some influence, it is more likely that weather and the availability of natural foods were the

chief factors involved. Nevertheless, if control of fox abundance through baits containing an antifertility agent is to be practical, a high proportion of a fox population must consume the baits to achieve a significant reduction in productivity. To the extent these results are representative, the distribution of antifertility agents early in he winter would be of little value, and substances that would be effective only when eaten by foxes prior to mid-January would be of little use. Additional field trials in representative areas of the State would be desirable to substantiate these observations.

For evaluating the effectiveness of antifertility agents, a method is needed by which animals that consume baits can be marked for later identification if they are trapped or otherwise collected for examination. Dyes, radioactive isotopes, or nontoxic metals stored in the bones or teeth may offer a solution to this problem.

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SELECTIVE BREEDING OF TROUT FOR RESISTANCE TO FURUNCULOSIS[1]

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ABSTRACT

A program of selective breeding has been carried on to develop strains of brook trout and brown trout resistant to furunculosis. Diverse geographical strains of these species, obtained from stations in the United States and Canada, were intensively exposed to *Aeromonas salmonicida*, the etiological agent, and the less resistant individuals were removed by mass selection. Survivors were retained as brood fish for the next generation which was similarly exposed to disease, etc. Hybridization through crossing more promising strains in some instances improved resistance. Typical data are presented to demonstrate the variation among fingerlings and yearlings of resistant strains and to compare them with control strains. Resistant strains were also compared with regular hatchery stock under actual hatchery conditions. Results obtained thus far indicate that resistance to furunculosis is being achieved. The work is continuing.

Furunulosis and ulcer disease, two bacterial diseases, have plagued trout growers with extensive losses for years. Chemotherapy and the use of antibiotics have been only partially successful in arresting them. Economically, in terms of fish losses and/or cost of drugs, a severe burden often results. In the fall of 1952, the late Dr. Louis E. Wolf, fish pathologist for the Conservation Department, originated a breeding program at the Rome Hatchery designed to develop strains of brook trout and brown trout that would be resistant to these diseases. The method of operating the project, as well as plans for physical facilities and personnel, were initially prepared by Dr. Wolf. He reported on the encouraging results obtained in the first 11 months of work and reviewed pertinent literature concerning breeding for disease resistance (Wolf, 1954). Because of certain complexities encountered in working with two diseases simultaneously, and because ulcer disease was definitely on the decline in this State, it was decided in 1956 to concentrate on furunculosis alone.

Improved resistance to disease by selective breeding appears feasible since variation in levels of resistance between strains within species commonly occurs. Hutt (1958) pointed out the influence of environment on the well-being of animals and stressed that the quality and quantity of food available, as well as the obvious physical factors such as heat, cold, drought and variations in the amount of light, interact with different genotypes to cause variation in phenotypic expression. Variation in incidence and virulence of pathogenic

[1] A contribution of Federal Aid in Fish and Wildlife Restoration Project F-2-R. The author is indebted to the late Dr. Louis E. Wolf and Richard I. Stevens who contributed much to the planning and techniques used in this research program. Also, Dr. Carl C. Lowe of Cornell University is especially thanked for his assistance in genetic procedures and review of the manuscript.

organisms and parasites to which the animals are exposed is an additional source of observed differences between individuals or strains. It is most important that comparable environmental conditions be maintained in screening strains for differences in disease resistance. Genetic diversity in the pathogen itself is also a possible complicating factor in observing variation in disease expression; this is a very important consideration in breeding and maintaining disease-resistant lines.

Species differences in disease resistance are striking. Rainbow trout are quite resistant to furunculosis, but many strains of brook trout and brown trout are extremely susceptible (Furunculosis Committee, 1933). Brook trout are also prone to ulcer disease whereas brown trout and rainbow trout are practically immune (Wolf, 1938). These differences are detectable both in laboratory experiments and in production hatcheries where the three species are being reard and epizootics have occurred.

Little work has been done on selective breeding of trout where disease resistance alone was the principal breeding objective. Embody and Hayford (1925) and Hayford and Embody (1930) reported on an experiment begun in 1919 in which two strains of brook trout were continued through five generations. Other desirable characteristics were sought during their work, but a marked increase in resistance to furunculosis, improved growth, and egg yield were noted. Snieszko *et al.* (1959) clearly showed a natural variation in resistance to ulcer disease and furunculosis among four strains of brook trout during an artificially induced epizootic.

Experimental work conducted under the present project has involved screening and selection under induced epizootic conditions as well as hydrization between selected lines. In the initial phase, a sustained effort was made to procure brook trout and brown trout strains from diverse sources throughout this country and Canada. A requisite for strains collected for screening was that each have a history of at least 8 years at the hatchery from which it was obtained. After the collected strains were exposed to disease, comparative mortality records indicated the degree of natural resistance manifested by them.

Survivors from strains showing the lowest mortality under induced epizootics were retained. In addition to maintaining the most resistant lines, crosses were made between better performing and, in some instances, intermediate performing strains in an attempt to achieve higher levels of resistance. On completion of the initial program, it was intended that selection for disease resistance should be accompanied by selection, within strains, of other desirable characteristics such as growth, coloration, egg yield, egg and fry viability, etc. Project planning calls for the distribution of selected lines to production

hatcheries when a superior product has been produced as indicated by comparison with existing standards. At the present time (1963–64) the screening of strains and strain crossings for disease resistance is nearing completion; field testing of several of the better performing strains is in progress and the first eggs from disease-resistant lines have been released to a production hatchery as potential brood stock.

It should be emphasized that the duration of a breeding project for disease resistance is conditional on the causal pathogen. A high level of resistance to existing forms of the organism does not necessarily ensure continued resistance against variant or mutant forms which may develop. Even if mutant forms of the pathogen do not develop, the breeding methods to which this project is restricted would be expected to approach improved resistance slowly rather than to suddenly achieve complete strain resistance. To prevent possible regression in selected disease-resistant lines, and to provide for the possibility of pathogen variation, a program of continuously exposing these lines to disease under controlled conditions will probably be a necessity.

PHYSICAL FACILITIES

Water supply for the project was derived from four sources: pure springwater piped in from a point where the underground supply emerged, an artificial lake harboring a reasonably heavy population of warm-water fish, a spring-fed creek which was tapped about one-quarter mile from its source, and so-called "used" water. This "used" water had passed through several ponds of trout connected with a production hatchery and was the supply, together with lake water, that fed ponds holding experimental yearling and older trout. Optimum conditions were not the objective in this age class; in fact, the opposite was sought. Temperatures of the springwater supply were well within the tolerance of brook trout, varying throughout the year from about 44° to 57° F. Lake water ranged from about 78° F. in summer to 34° F. in winter. Tempering of lake water with springwater was possible and was generally done when desired or necessary.

Eighteen wooden rearing trough, 13½ feet long x 21 inches wide x 9½ inches deep, were used until 1955 when they were replaced with steel troughs measuring 14 feet x 23¾ inches x 10½ inches. Each trough was divided in two with a screen, providing an annual total holding capacity of 36 lots or strains.

Fourteen concrete ponds, 20 feet long x 7 feet wide x 4 feet deep, were used for holding yearlings and brood fish. Each pond was so designed that it could be divided into thirds by the insertion of screens, giving a total pond potential of 42 strains. Pond bottoms of gravel were replaced with concrete in 1958.

Prior to 1959 all incubation of eggs was done in conventional screened boxes in small laboratory troughs with a direct water flow through each. In the fall of 1959, a vertical incubator was put into operation to conserve both space and water. This incubator was modified to an extent by compartmenting the egg trays to increase the number of strains which could be incubated and kept separated.

OPERATIONAL METHODS

The method being used to obtain improved resistance is essentially "mass selection" within strains showing resistance or crosses between such strains. Trout which have survived an artificially induced infection are retained (selected) as brood fish in order to produce a new generation with a greater frequency of resistant individuals. This new generation is again exposed to disease and again the survivors are used as breeders, etc. Spawn is taken from trout as soon as they mature: for brook trout this is 1+ years and for brown trout it is 2+ years.

In the original planning of the experiment it was reasoned that line resistance might improve if the fish within a line were subjected to repeated exposure year after year. Spawn collected annually would be a measure of the change in resistance of the line as susceptible breeding parents were eliminated in the original line population. While this procedure is possibly desirable for simultaneously selecting for longevity, it is not an efficient means of selection against a disease which is most critical during the earlier rearing period.

A policy change was adopted in 1955 which concentrated on recombination of resistant genes in line progeny rather than on continued elimination of non-resistant individual survivors in a single generation. Emphasis was placed on expediting the project through concentration of resistance in succeeding generations. By eliminating parent line fish after their first year of maturation, available pond space could be used more efficiently and selection directed to the critical rearing period.

All fingerling lots were kept in rearing troughs until late fall or until after the spawning season. At this time spawned-out lots of brood fish were removed from the ponds and replaced with selected fingerling strains of the next generation. This general cycle normally worked quite well although exceptions to it were sometimes needed. Occasionally, breeders which had spawned were retained, particularly those from promising strains which merited extra caution for preservation or where a record was doubtful and a performance recheck of the progeny in the following year was warranted. Brown trout offered a special problem since pond space had to be provided for both yearlings and 2-year-old fish because of their delayed sexual maturity.

A number of fingerling lots whose resistance performance might be classified as intermediate had to be discarded because of the very restricted space facilities. Since second or third generation of resistant strains would have been extremely difficult to replace, the decisions on how best to use limited pond facilities were often exceptionally difficult.

Intensive selection for one particular character may result in other traits of the line becoming inferior to set standards if the genes involved control the expression of more than one character. Data on growth, egg viability, fry and early fingerling losses were kept but, so far, disease resistance has been given primary consideration. There has been no detectable association between disease resistance and undesirable expression for any secondary character.

The procedure of taking eggs from first spawners to shorten the generation cycle can be criticized since this constitutes some selection for early maturity and may be undesirably associated with growth and longevity factors.

Mediocre incubation facilities, which have varied from year to year with respect to water temperature and turbidity, have resulted in egg and fry losses of a questionable level. Also, the use of first eggs, which are frequently low in quality and are often not even considered in production hatcheries, could well have contributed to high mortalities. Strain variation for egg and fry losses was observed but is believed to be of little consequence at this time.

EXPOSURE TO INFECTION

The method of exposing trout to furunculosis remained fairly uniform during the course of the project. Mixing ground, diseased trout into the regular diet was discontinued after the first year. Instead, a constant source of the disease was maintained during the summer when water temperatures were favorable for its perpetuation. This was accomplished by inoculating healthy trout with virulent strains of *Aeromonas salmonicida*, the etiological agent, and placing them within a wire-mesh enclosure in the incoming flow of water to ponds or troughs. When an epizootic got under way, several moribund fish from strains being tested were placed daily into the wire basket while the dead individuals from the previous day were removed. Moribund fish were examined bacteriologically at frequent intervals to ascertain positively that fish were dying of furunculosis and not from other causes.

A few problems encountered should be mentioned to avoid over-simplification. As in most hatcheries, conditions and diseases that are not supposed to occur sometimes developed. Catastrophes such as water failures, broken or plugged screens, excessive hidden

mortalities and even vandalism were encountered. Besides these, other trout diseases than furunculosis appeared from time to time. Data considering only resistance to furunculosis was the objective but, in some instances, other infections obviously affected results. When an outbreak of an extraneous disease occurred in a particular strain, treatment with the indicated medication was immediately started and administered to all strains in the experiment so as not to introduce another variable.

Except where noted, all strains, both fingerlings and yearlings, were rigorously exposed to artificially induced infection from approximately June 15 to November 1. After November 1, few deaths attributable to furunculosis occurred. Adjustments in populations for number and density were established prior to exposure to disease. Inventories (total weights and counts) of fingerling lots were taken monthly and, where densities exceeded a predetermined level, thinning was done to reduce populations. "Hidden" mortalities were spotted during the inventory and corrected totals were set up on which to base percentage mortalities for the ensuing month. Insufficient emphasis on this control of population densities during the first three or four years of the project probably led to some questionable data. In 1958, a change in policy relative to inducing infection was inaugurated. For reasons explained under the next topic, it was deemed advisable to infect only yearling trout and attempt to keep the fingerlings disease-free.

TREATMENT OF DATA

Criteria used in choosing desirable strains, i.e., those which showed greater resistance to furunculosis, were based on percentage survival (on a comparative basis) throughout an epizootic. As mentioned earlier, data on growth, egg losses, fry and early fingerling losses were also taken but, to date, no strains have been rejected on these characteristics.

Referring to the policy change adopted in 1958 relative to fingerling infection procedures, it was decided that resistance data based entirely on the percentage of survival or loss resulting from an epizootic could have certain invalidity. It seemed likely, although this was not proven, that trout in the lower-most troughs were being subjected to greater numbers of disease organisms after the epizootic became well established than fish in the troughs above. To clarify this point, troughs were placed in series of three with water passing from the upper through the lowermost. Also, population densities, while adjusted at the beginning of a month, did not remain comparable in all lots because of the differentials in growth and mortality. But, more frequent adjustment was not feasible. The variation in tem-

peratures, although the difference was not more than 1° to 3° F. between upper and lower troughs, was also a possible source of error. Of greatest concern, however, was the possibility of developing acquired immunity through the disease-exposure methods used. This would seriously interfere with the objective, inherited immunity. To eliminate this possibility a new technique was devised to evaluate strain performance of fingerlings.

This method involved transferring a number (depending on size but generally not exceeding 100) of fingerlings from each parent lot to a 2-gallon aquarium. Originally, fish were graded as to size so that the range within a given lot did not exceed ½ inch. This sometimes resulted in choosing smaller fish from a faster growing strain and larger fish from a slower growing strain to obtain comparable sizes. Consideration was given to the fact that higher or lower resistance might be related to size or rate of growth. To eliminate this possibility, two size groups were taken from each strain while still retaining comparable sizes between strains.

Within each aquarium holding a strain of trout, the factors of temperature, flow, density, dissolved oxygen, and the number of organisms used to infect could be controlled. The number of organisms (inoculum) was controlled by mass cultivation of virulent strains of *A. salmonicida* on nutrient agar in Roux bottles and adding similar measured amounts to each aquarium. Aliquots of up to four geographic strains of bacteria were used per test with a minimum of three separate tests being performed per species from June through September. Suspensions of bacteria were measurd in a photoelectric colorimeter, the stock concentration varying from 25–50 per cent transmittance at a wave length of 525 mμ per batch of inoculum. Fish were not fed during the testing period.

The organisms (100 cubic centimeters of stock suspension) were added to 1 gallon of water holding the fish to be tested. There was no water flow to the aquaria during the exposure but oxygen was added through carborundum liberators. Exposure time was 2 hours per day on two successive days. Generally a constant temperature of 58° F. was adequate for "sufficient kills" of brook trout, while brown trout required 62° to 64° F. A "sufficient kill" was considered to be in excess of 50 per cent of the fish within a period of 7 to 10 days after termination of the last exposure.

Mortality generally started on the third or fourth day after the final exposure. Readings (counting mortality and recording time of death) were taken at regular intervals, the spacing being regulated by the number of fish used in the particular test and the rate at which they died. Regression curves were plotted for each strain on arithmetic probability graph paper (Codex 3227), i.e., logarithmic time of death

against percentage mortality, to obtain the ST_{50} value (survival time in hours for 50 per cent of the fish).

Some complications developed on occasion to interfere with the effectiveness of this newer testing technique. A spontaneous outbreak of furunculosis occurred in several fingerling strains in 1958 (the first year the new testing technique was used). Sulfamerazine and terramycin therapy did not totally arrest the outbreak. Results of tests using drug-influenced fish, strains recovering from the disease, or strains that apparently never contracted the disease were erratic and certainly could not be considered valid.

Difficulties were also encountered within the tests. Insufficient mortality (under 50 per cent) was sometimes experienced making it impossible to set up regression curves, or the time lapse between exposure to disease and adequate losses was too great. Too long an interval could not be accepted because of possible interference by such factors as starvation and acquired immunity which obviously would influence the results of the tests.

It was deemed necessary, for valid aquarium testing, to use fish that were furunculosis-free, and it was also necessary to strenuously expose fingerlings to the disease in order to eliminate susceptible individuals in this important age class if selection was to be effective. For three years, the total fingerling populations were not infected. A policy change in 1961 corrected this by arranging to complete all testing by mid- or late September; this could then be followed by severe and intensive exposure of the fingerling populations throughout October while the water was still warm enough to establish fulminating epizootics.

RESULTS

Presentation of complete data acquired through more than 10 years of experimentation is not practicable. Some strains which performed well in one year did not maintain the same resistance level in suceeding years. Restricted facilities and procedural changes interfered with the objective of an orderly progression towards optimum resistance involving several strains of trout. Possible mutation within the bacterium itself, as well as a more generous use in later years of multiple geographic strains of the causal organism, were also a deterrent to continuous year-after-year peak performance of particular lines.

Therefore, data typical of those now being acquired annually to evaluate fingerling strain performance are given in Tables 1 and 2. In some of the better performing brown trout strains it has become increasingly difficult (hopefully because of greater resistance) to cause sufficient mortality for projecting ST_{50} values. For this reason, percentage survival values were used in 1962 to rank the strains for this species.

Table 1. Resistance of Various Strains of Brook Trout Fingerlings to Furunculosis in Three Tests Using Different Geographic Strains of *A. salmonicida* in Each Test—1962*

Strain §	Test 1 (100 fish) †	Test 2 (100 fish) †	Test 3 (60 fish) †	Average
45–62	169.0	163.6	131.8	155.5
32–62	163.6	150.3	123.9	146.6
31–62	161.1	161.1	111.9	141.7
30–62	159.2	151.2	112.7	142.0
15s–62	166.0	135.5	123.0	141.8
16–62	151.9	147.9	119.4	140.7
23–62	158.5	144.9	117.3	140.4
25–62	169.3	140.9	111.6	138.6
11–62	142.6	138.7	123.5	136.6
15aaa–62	131.5	145.5	120.8	132.6
39h–62	147.9	145.2	101.6	131.6
18–62	149.3	140.6	99.8	129.9
5–62	145.9	132.7	104.0	127.5
17–62	148.9	129.7	100.9	126.5
6–62	134.3	131.3	107.6	125.4
62R (control)	141.3	140.0	89.5	123.6
21–62	134.6	118.6	102.8	118.6
Average	151.2	142.6	112.4	135.4

* Values expressed as ST_{50} hours; least significant difference at P = .05 level of probability = 13.4 hours.
§ Ranked according to average degree of resistance.
† Length ranges were 2.00–2.50 inches, 2.25–2.75 inches, and 2.75–3.25 inches for fish in Tests 1, 2 and 3, respectively.

The obvious variables between tests for fingerling resistance were age, number and size of fish, and bacterial strains used for infection. Other, somewhat obscure, variables might include changing densities in troughs from which fish to be tested were taken and temperature. Because of these factors, each test had to be considered an entity in itself. Optimum performance of a strain was based on its ability to rank highest or reasonably high in all tests.

Control strains are designated in both tables as 62R. These strains had undergone no selection other than what might be considered random at the hatchery from which they came. This particular hatchery has not experienced an epizootic of furunculosis in many years.

Another consideration is the amount of variation that might occur in survival values if duplicate strains were run in the same test. This has been tried a number of times with favorable results. In fact, the percentage survival values for Strain 37–62 brown trout in Test 1 were 44.0 per cent for one lot and 41.0 per cent for its duplicate; they averaged 42.5 per cent.

Typical examples of yearling performance are given in Figures 1

TABLE 2. RESISTANCE OF VARIOUS STRAINS OF BROWN TROUT FINGERLINGS TO FURUNCULOSIS IN THREE TESTS USING DIFFERENT GEOGRAPHIC STRAINS OF *A. salmonicida* IN EACH TEST—1962*

Strain §	Test 1 (100 fish) †	Test 2 (75 fish) †	Test 3 (60 fish) †	Average
38–62	89.0	64.1	69.7	74.4
31–62	91.1	64.9	52.5	69.6
9–62	83.1	64.3	58.3	68.7
4–62	67.7	58.7	53.3	59.9
9–61a	63.1	39.5	45.0	51.0
53–62	41.5	60.8	35.6	46.0
54–62	41.5	53.3	36.7	43.6
39–62	28.0	41.9	43.3	37.7
12–62	38.1	40.0	31.7	36.7
37–62	42.5	14.9	50.8	36.1
52–62	37.0	29.3	20.0	28.8
35–62	15.8	26.8	37.3	26.6
51–62	22.0	32.0	11.7	21.9
62R (control)	22.7	22.0	6.4	17.0
Average	49.2	43.8	39.5	44.1

* Values expressed as percentage survival; least significant difference at P = .05 level of probability = 33.8 per cent.
§ Ranked according to average degree of resistance.
† Length ranges were 2.25–2.75 inches, 2.75–3.25 inches, and 2.75–3.25 inches for fish in Tests 1, 2 and 3, respectively.

and 2. Among eight brook trout strains tested, losses ranged from 57 per cent for the control group to 12 per cent for the best performing strain. Of nine brown trout strains, the control was also poorest with a loss of 57.5 per cent against 19.5 per cent for the best performing strain. It did not always follow that the best performing strain among the fingerlings also ranked highest when tested as yearlings. The reason for this is unknown; perhaps resistance mechanisms vary at different ages. It is encouraging that almost invariably the control strain made the poorest showing in both fingerling and yearling tests.

Since 1959 a program of testing has been practiced whereby some resistant strains have been released, either as eggs or small fingerlings, to State production hatcheries. Data have been acquired, generally through the ensuing summer, for comparing the resistant strains with the run-of-the-mill hatchery stock; comparisons included growth, general behavior, resistance to furunculosis and susceptibility to other diseases. While the hatcheries chosen have all had histories of furunculosis, it could not be precluded that the disease would occur when the selected strain was being tested. In fact, the contrary was frequently the rule. Two instances may be cited, however, in which a reasonably severe epizootic of the disease did occur while selected stock was in the hatcheries involved.

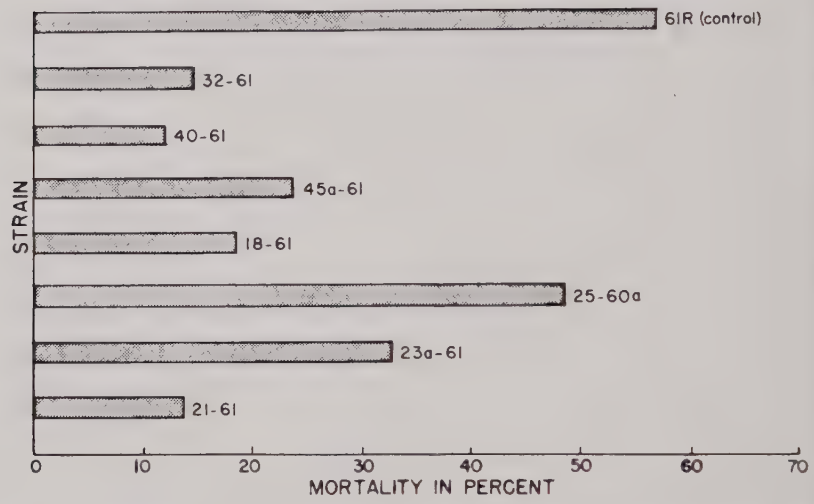

Figure 1. Resistance to furunculosis demonstrated by several strains of brook trout yearlings after sustained exposure to the disease during the summer of 1962.

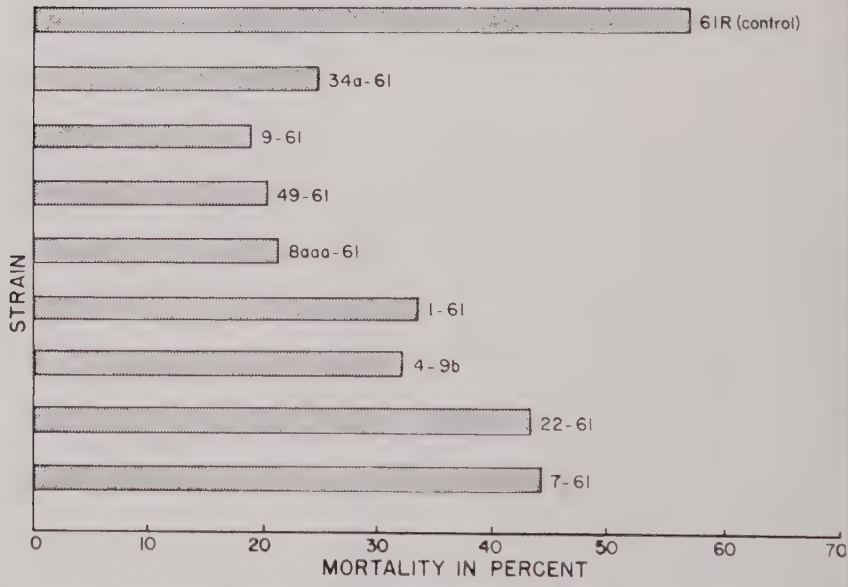

Figure 2. Resistance to furunculosis demonstrated by several strains of brown trout yearlings after sustained exposure to the disease during the summer of 1962.

In 1961, two adjacent ponds at the foot of comparable series each held 25,000 brook trout fingerlings—one lot, a selected strain; the other, average hatchery stock. In June, the control lot averaged 160

fish per pound while the resistant strain ran 219 per pound; by August this differential had narrowed to 39.8 per pound vs 42.1 per pound. Furunculosis was diagnosed in both lots during September. Losses became so high in the control group that economy and preservation of fish dictated administration of sulfamerazine to arrest the outbreak. The selected strain received no medication. During the period July 1 to December 1 losses in the control lot were 8.55 per cent compared with 1.88 per cent in the test lot. These losses represent a minimum measure of the relative disease resistance of these two strains of fish. Presumably, the gap would have been much wider if corrective therapy had been delayed or had not been administered to the control lot.

In 1962, at another hatchery, 19,000 selected brook trout fingerlings were being held. In mid-September a severe epizootic of furunculosis complicated by gill disease was diagnosed in the regular hatchery stock. Corrective therapy was immediately started except that no internal medicine was administered to the selected strain. Losses for the remainder of the month amounted to 7.3 per cent for the hatchery fish and 0.17 per cent for the furunculosis-resistant strain. During October, 14.5 per cent of the hatchery stock were lost despite sustained drug treatment. While *A. salmonicida* was isolated from the kidneys of several moribund, selectively-bred fish, medication was again withheld. Despite this and the fact that these fish were positioned in a common-flow series between two ponds of hatchery stock each suffering heavy losses, mortality was calculated at only 0.64 per cent.

It should be pointed out that testing selected strains against the regular stock in a hatchery is difficult because comparable conditions can seldom be achieved. Production hatcheries must operate at maximum efficiency to fulfill stocking needs of the State. Frequently there are differences in size, position, density and numbers; unavoidably, these and other variables may influence results. However, results obtained thus far indicate that selective breeding for disease resistance is achieving its purpose.

DISCUSSION

This is an interim report. The work is still in progress. Since 1958, a method of testing fingerlings has been used whereby homogenous samples from strains to be tested were exposed to the disease in such a manner that the variables of temperature, water flow, dissolved oxygen, fish size and density, total numbers of infective bacteria and, probably, acquired immunity were eliminated or kept at a minimum. Testings of yearling fish have remained constant in that total adjusted populations are subjected to intense and sustained exposure to furunculosis. Percentage survival after a predetermined period is the index used to evaluate resistance.

Considerable variation in disease resistance has been found among geographic strains. This could well have originated through natural selection in production hatcheries where the disease has been present. Mass selection within resistant strains appears to be improving resistance in succeeding generations; crossing better performing strains has, in some instances, resulted in even further improvement. Consistent year-after-year peak resistance has not always been the rule. Interaction with environmental variables or variation in the causal pathogen itself are possible explanations.

By necessity, breeding procedure has thus far been restricted to selection within, and crosses between, strain populations. This procedure minimizes the danger of chance fixation of undesirable characteristics, but this could occur through association with the main selection character. Future planning calls for a reduction in the number of strains with retention of only the best. This would facilitate developing new lines by selection and mating of individuals. Such a procedure may be necessary to combine a high level of disease resistance with other highly desirable characteristics such as rapid growth exceptional egg yield, high egg and fry viability, color and body form

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SOME EXPERIMENTAL SHRUB PLANTINGS—20 YEARS LATER[1]

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ABSTRACT

Experimental plantings of various shrubs, made in the early 1940's on two sites representative of the submarginal and abandoned uplands of southern New York, have provided valuable information on their survival, hardiness, adaptability to adverse sites, fruiting, susceptibility to weather and disease, damage by wildlife, and usefulness to wildlife for food. Many species were found unsuitable for one reason or another, others succeeded where their original value was doubtful, certain species have shown enough promise to call for further trial, and 6 species are now being regularly produced in quantity for erosion control, wildlife use, or both.

Beginning in 1939, the U. S. Soil Conservation Service, in cooperation with the New York State Conservation Department, made experimental plantings of shrubs on several of the State's game management areas on the submarginal and abandoned uplands of southern New York. After three growing seasons, observations on survival and growth for the shrubs planted on the Partridge Run Game Management Area in Albany County were reported by Cook and Edminster (1944). Observations on all plantings made in the State were included in a general report on wildlife shrub plantings by Edminster and May (1951). The present author has made various observations since 1946 on the plantings on the Partridge Run Game Management Area and on the Connecticut Hill Game Management Area in Tompkins County. Information gained from this study is being employed in evaluating the choice of materials used in New York's shrub planting program.

It seems desirable to comment on the status of these plantings 20 years after the final planting dates. For a few species, observations made at locations other than the two test sites are included. Emphasis is on the ability of the various plants to survive and grow on the poorly drained, sterile, generally acid soils, described by Cook and Edminster (1944), in competiton with poverty grass (*Danthonia*), goldenrods and asters and on their potentialities as sources of food for wildlife.

OBSERVATIONS

Observations on the status of the plantings are summarized in Table 1 and are commented on separately for the 61 species on which data were obtained. The number of plants set out varied consider-

[1] A contribution of Federal Aid in Fish and Wildlife Restoration Project W-88-R. The original plantings by the U. S. Soil Conservation Service were made under the direction of Frank C. Edminster, then regional biologist for the northeastern states.

Table 1. Summary of Observations on Trial Plantings of 61 Shrubs on Two Upland Areas in Southern New York

Shrub	Survival				Growth				Spread				Fruiting success				Fruits available			Limiting factors						Future study			Use	
	None	Poor	Fair	Good	None	Poor	Fair	Good	Stolons	Seeds	Any soil	Dry soil	None	Poor	Fair	Good	Summer	Fall	Winter	Climate	Soils	Disease	Insects	Animals	No wildlife value	Further trial	In production	Food and/or cover	Erosion and control
Amelanchier intermedia			*			*							*				*								*				
Amelanchier oblongifolia		*				*							*				*								*				
Amorpha fruticosa			*	*			*		*							*					*				*			*	
Aronia melanocarpa				*		*			*					*							*				*				
Berberis thunbergii				*		*				*					*						*				*				
Celastrus orbiculatus				*		*			*				*										*						
Celastrus scandens				*		*			*				*										*					*	
Cornus Amomum				*				*	*						*		*									*			
Cornus bretschneideri				*				*	*						*		*												
Cornus mas				*				*			*				*			*				*					*		
Cornus racemosa				*				*			*					*		*											
Cornus stolonifera				*				*	*		*					*													
Corylus americana x avellana								*							*			*		*	*						*		*
Cotoneaster divaricata			*			*								*	*			*		*	*	*				*			
Crataegus monogyna			*			*															*								
Crataegus pedicellata			*			*														*	*				*				
Elaeagnus angustifolia	*																				*				*				
Elaeagnus commutata	*																								*				
Elaeagnus umbellata				*				*		*		*				*		*									*		*
Euonymus europaeus			*			*							*								*								
Lespedeza cyrtobotrya				*				*	*							*		*		*						*	*		
Lonicera bella		*				*															*								
Lonicera maacki				*			*																			*			*

ably. Unless otherwise noted, it may be assumed that at least 20 plants of each species were set out at each test site. In several instances, plantings were made on one area only. Since 1956 some necessary maintenance has been carried on to reduce encroachment of other vegetation.

Since, with the passage of time and loss of labels and planting records, it was not always possible to determine how many plants were set out, general terms have been used to indicate survival. Poor, fair, good and excellent survival should be considered to represent roughly under 20 per cent, 21 to 50 per cent, 51 to 75 per cent and over 75 per cent, respectively.

Amelanchier intermedia Juneberry

One planting on Connecticut Hill has fair survival and has attained an average height of 4 feet.

Amelanchier oblongifolia Thicket serviceberry

One planting on Connecticut Hill showed poor survival, and has reached a maximum height of only 32 inches. The serviceberries, or juneberries, are generally found as native plants in some abundance on these upland sites and they fruit at a season when food is not a problem, so there seems to be little advantage to planting them.

Amorpha fruticosa Indigobush amorpha

A planting on a dry hillside on Connecticut Hill had fair survival, attained a height of 6 feet and flowered and fruited fairly well. Another planting in a shallow roadside ditch did far better in survival, growth and fruiting. Its value as a wildlife plant in New York seems doubtful. Related species, also, were poor in survival and growth.

Aronia melanocarpa Black chokeberry

Plantings at Partridge Run survived well and fruited early. There was some spreading by stolons, but the plant did not dominate its site. Wildlife did not seem to make any use of the fruits, hence it cannot be recommended for further plantings.

Berberis thunbergii Japanese barberry

Plantings at Partridge Run survived well, but plants have grown slowly. That Japanese barberry has been observed to grow vigorously and to spread by seeds on acid, sandy sites elsewhere indicates tha

it is unsuited to heavy, poorly drained soils. Fruiting was good, but there seemed to be little wildlife use.

Celastrus orbiculatus Oriental bittersweet
Celastrus scandens American bittersweet

Plantings at Connecticut Hill and Partridge Run survived well and have spread by runners, but in both places browsing by deer kept these to within a few inches of the ground. A few stems escaped to fruiting size by climbing pines. These species seem better suited for erosion control on roadbanks or for use as ornamentals than for wildlife plantings, and the American bittersweet seems preferable.

Cornus Amomum Silky dogwood

All plantings of this species have grown vigorously and have taken complete control of the sites. Fruiting was fairly constant, but because the fruits ripened in early September they were quickly removed, mostly by songbirds. The natural abundance of this shrub, coupled with its somewhat ephemeral wildlife value, indicates that it would be better used for purposes other than wildlife plantings.

Cornus Bretschneideri Bretschneider dogwood

Plantings at Connecticut Hill and Partridge Run of this import from Asia have attained control of the sites and have reached heights of 6 to 8 feet. But there seems to be no reason for using it in place of either *Cornus Amomum* or *C. stolonifera,* to which it is similar in growth.

Cornus mas Corneliancherry dogwood

One planting on Connecticut Hill has continued to look better over the years; 64 per cent of the plants survived and after 20 years were 6 to 12 feet tall and rather fastigiate, unlike the usual spreading form. Fruits were produced fairly abundantly and ripened in October, rather than in August as would be typical. They were eaten by squirrels from fall to spring, and for this reason the plant should be given further trial.

Cornus racemosa Gray dogwood

One planting at Partridge Run took early command of its planting site and has continued to spread strongly by stolons, so that it has become difficult to control. Fruiting was abundant, and use by wildlife was greatest in October and early November, mostly by migrating

songbirds. Its widespread distribution in New York would seem to make it unnecessary to plant this species.

Cornus stolonifera Red-osier dogwood

Plantings at Partridge Run of silky dogwood turned out to be partly this species, and in fact the two might be used interchangeably on all but the drier sites. Its fruiting time is somewhat later but not enough to make it of value as a winter food for wildlife.

Corylus americana x *avellana* Hybrid filbert

Plantings on the two areas have survived and grown well, to 12 to 15 feet in height. Fruiting in recent seasons has been erratic because of winterkill of flower buds or injury to the flowers by severe spring frosts; the species is near its limit of hardiness in New York. The filberts ripened in September, but were almost immediately taken by squirrels. Thus, seed collection by man is uncertain, and if nuts are to be harvested the plantings must be kept isolated from woodlands.

Cotoneaster divaricata Spreading cotoneaster

Three of the four plants set out on Connecticut Hill survived and produced fruit, but late spring frosts and fire blight set them back repeatedly. Under favorable conditions, several of the cotoneasters fruit very well and are used for food by wildlife, but none seems suitable for planting where special care cannot be given.

Crataegus monogyna Hawthorn
Crataegus pedicellata Hawthorn

Plantings of these two hawthorns, the former from Europe and the latter a native, have grown slowly. Maximum height after 20 years was only 6 feet and fruiting has been poor. Nature seems to do a better job than man at planting hawthorns. The opportunities to convert the wild hawthorns to more desirable wildlife plants by top-grafting them to persistent-fruited hawthorns would seem to offer a better method of getting good ones distributed.

Elaeagnus angustifolia Russian olive
Elaeagnus commutata Silverberry

No plantings of these species seem to have survived. Their requirements for a fertile, high-lime soil would seem to be the limiting factor rather than low winter temperatures. Although Russian olive

grows well at the Painted Post Nursery, plants set out on poorly drained, sterile soils declined each year.

Elaeagnus umbellata Autumn olive

Of two plantings on Connecticut Hill, one attained a height and spread of 12 feet, whereas the other winterkilled repeatedly and was browsed back annually by deer. Fruiting started at an early age and was usually profuse. The fruits were eagerly sought by birds and squirrels. There was a wide range in fruiting dates for individual plants, from late July to early November, and trials are in progress to learn whether this is a seed-constant characteristic. Reproduction is abundant in sandy soils. Autumn olive seems best suited to relatively dry sites, but it will be winterkilled in wet spots. With its spiny branches, it might be considered for a fairly good, tall hedge.

Euonymus europaeus European euonymus

Plantings on both areas have grown slowly, with considerable spreading by stolons, but height growth and fruiting have been poor. Only one plant attained 6 feet in height. The Connecticut Hill plantings are now being browsed by deer. Except for this, and the stoloniferous habit, the species seems to offer little promise for wildlife use.

Lespedeza cyrtobotrya Cyrto lespedeza

One planting at Partridge Run survived well, has attained a height of 7 to 8 feet, and has been fruiting well since 1946. Flowering starts in July and continues until halted by late September frosts. Seeds ripen in early November, but soon fall to the ground. Because of the success of this planting in poor soil at 1,600 feet elevation, additional plantings have been made from this seed source to determine its general suitability and actual wildlife value for pheasants, grouse, turkeys and quail.

Lonicera bella
Lonicera muendeniensis
Lonicera notha
Lonicera syringantha

All of these honeysuckles had poor survival and growth, so that none seems worthy of further consideration for this type of site.

Lonicera maacki Amur honeysuckle
Lonicera maacki podocarpa

No plantings of *L. maacki* were made on either area. The variety

podocarpa grew poorly on Connecticut Hill, but observations on both, elsewhere, suggest they are worthy of further consideration because of their late fruiting habit. Fruits of *L. maacki* ripen in October and November. Fruits of var. *podocarpa*, however, do not ripen until late December, which would indicate it has advantages as a winter food producer, if it proves to be hardy and adaptable.

Lonicera morrowi Morrow honeysuckle

One planting on Connecticut Hill averaged 32 inches in height after 20 years. Fruiting was sparse, so that this species can be dropped from consideration in favor of the more vigorous *L. tatarica*.

Lonicera quinquelocularis Mistletoe honeysuckle

One planting at Connecticut Hill survived but grew poorly, which may indicate a lack of hardiness. This Himalayan species has attracted interest because its whitish, translucent berries are not mature until late December when they are eagerly sought by birds.

Lonicera tatarica Tatarian honeysuckle

This species apparently was a failure at Connecticut Hill, but plantings elsewhere have been eminently successful and useful. Consequently it is a regular production item at the Painted Post Nursery. Because its fruit ripens in August and September it is used primarily by songbirds. It spreads from seeds in sandy soils so that it may present a control problem. Its height and spreading nature make a fine travel lane for game species.

Malus sargenti Sargent crab apple

This species is naturally dwarft, so that at Connecticut Hill plants averaged only 4 feet in height. It has fruited well nearly every season and holds its fruits until midwinter. Considerable use of the fruits by birds of all kinds has been observed. As a result of heaving of the plants, numerous sprouts have developed from the exposed roots, so the plants are assuming a colonial habit. This would be advantageous in offsetting girdling by mice and rabbits, which may destroy plants created by the customary budding process used by nurseries to produce named individuals or clones.

Malus sieboldi Toringo crab apple

One planting at Connecticut Hill had excellent survival, and has fruited well since 1956. Plants vary from 3 to 10 feet in height, with

an average of 5 feet, on this adverse site. Toringo crab is an annual bearer, and is produced in some quantity from seed at the Painted Post Nursery. Its fruits persisted well into February and were eagerly sought by wildlife. It should be pointed out that other crab apples are even better for fruit persistence, since some hold their fruits until March and April.

Myrica pensylvanica Bayberry

One planting at Partridge Run survived and grew well, began fruiting by 1946, and has spread steadily but slowly by stolons and seeds since that time. Bayberry is native to upstate New York on dry, sandy to gravelly sites, and is very abundant on Long Island in similar situations. However, it has been found growing wild on dry sites on Connecticut Hill, indicating its adaptability even to the Volusia-Lordstown soil types. It is a dioecious species.

Phellodendron amurense Amur corktree
Phellodendron lavallei Lavelle corktree

Plantings of these two species on Connecticut Hill had poor survival and have grown very slowly, being only about 4 feet high after 20 years. In 1957 new growth was killed back by a frost before May 8, and since that time additional injury has been caused by deer browsing. Neither species shows much promise of value for wildlife, although under better growing conditions the abundant fruits are persistent most of the winter.

Physocarpus opulifolius Ninebark

One planting on Connecticut Hill has survived and grown well, to an average height of 9 feet. It flowers and sets seeds annually in abundance. Its wildlife value seems to be nil.

Prunus americana American plum

Plantings on Connecticut Hill and Partridge Run have reached a height of 7 feet or more, but fruit production has been sparse. Because black knot sooner or later becomes a serious disease, the American plum is not a satisfactory wildlife plant on these submarginal, upland areas.

Prunus besseyi Western sandcherry

Western sandcherry was planted on both areas and survived fairly well, but fire blight and annual browsing by deer have kept the plants less than a foot high. If fruit is produced it is usually affected by brown rot, so that the species is not suitable for use in this area.

Prunus japonica Japanese bushcherry
Prunus tomentosa Manchu cherry

Plantings of these two species on Connecticut Hill failed to survive. Both are susceptible to fire blight and should not be considered for wildlife plantings in New York under these conditions.

Prunus maritima Beach plum

In two plantings at Connecticut Hill, more than half the plants were still alive and growing in 1956, but growth was very poor. In 1962 the tallest plant was only 18 inches high. Deer have browsed these plants considerably in recent years. Garden plantings of this species in better drained soils have succeeded, and some of the fruits have remained on the plants into November. Plantings might be more successful in sandy soils similar to those of the coastal plain where this species grows naturally.

Rhamnus cathartica Buckthorn
Rhamnus davurica Buckthorn

One planting labeled as *R. cathartica* on Connecticut Hill is apparently a mixture of this and *R. davurica*. Survival was poor and growth was lank, with no fruiting seen. Neither plant seems worth considering further for wildlife plantings on poor upland soils.

Rhus aromatica Fragrant sumac

Plantings on Connecticut Hill are only 15 to 18 inches tall after 20 years. They have spread by stolons, but no fruiting has been observed. This species seems to have little value for wildlife plantings on the poorly drained, sterile soils of New York's Southern Tier counties.

Rhus copallina Shining sumac

The planting on Connecticut Hill attained a maximum height of only 30 inches, and no fruiting was observed. Plants spread widely by stolons. Shining sumac seems better suited to dry, sandy or rocky soils which are its usual habitat.

Rosa multiflora Multiflora rose

Plantings on Connecticut Hill survived but have grown poorly to a maximum height of 4 feet, with much dieback of canes and little fruit production. Plantings at Partridge Run in a more sheltered situation have grown vigorously and fruited well. The bushes have

reached an average height of about 6 feet. Observations in southwestern New York, and in the Hudson Valley south of Albany in the spring of 1961 after a particularly severe winter, revealed extensive winterkill of many plants in hedge plantings. It is evident that multiflora rose is at the limit of its hardiness in upstate New York. Experience also has shown that it will not stand "wet feet". Therefore, planting sites must be chosen carefully. The writer has not heard or seen any examples of plants seeding in upstate New York.

Salix purpurea Purple-osier willow

No attempt was made to study this or other willows because of their limited wildlife uses. The purple-osier willow is in regular production at the Painted Post Nursery for use in erosion control, particularly in streambank plantings.

Shepherdia canadensis Buffaloberry

One planting on Connecticut Hill was a complete failure. Buffaloberry is a native to New York, occurring on dry, limy soils, usually at the edge of rocky banks. Its fruits are attractive to birds, but, ripening in June and July, they soon are consumed. The plant is dioecious, which is another reason for eliminating it from consideration for wildlife plantings in this State.

Sorbus americana American mountain ash
Sorbus Aucuparia European mountain ash

On Connecticut Hill, only one plant of *S. Aucuparia* survived; this was 18 feet tall and 5 inches in diameter. Plantings of both species at Partridge Run have become retrogressively smaller as a result of browsing by deer, so that they now can be located only when new growth starts in the spring. Near Delmar (N. Y.) the fruits of *S. americana* ripen in early October, when migrating songbirds promptly use them. The fruits of *S. Aucuparia* persist until November or early December when they, too, disappear. The susceptibility of both to stem borers makes them poor materials for wildlife plantings.

Symphoricarpos albus Snowberry

Plantings at Partridge Run have done poorly, partly because of browsing by deer. Fruiting was poor, and little use by wildlife was noted.

Symphoricarpos orbiculatus Coralberry

There is no record available of plantings of this species on either

of the two management areas. Coralberry until recently was a regular production item at the Painted Post Nursery because of its value in erosion control on roadbanks and in similar situations where it can be kept from spreading to where it is not wanted.

Taxus canadensis Canada yew

Plantings at Partridge Run survived after 20 years, but plants were only a few inches tall. Plantings of any of the yews were practically destroyed by deer, which apparently can consume them with impunity although cattle are poisoned. Yew is a preferred food of white-tailed deer, and one of the first woody plants to be eliminated by browsing.

Viburnum cassinoides Wild raisin

One planting so identified at Connecticut Hill was actually *Viburnum Lantana* and reported under that species. It is interesting to note that a direct seeding of the wild raisin made by David B. Cook in 1940 at Partridge Run has resulted in an excellent hedge about 6 feet tall which has fruited abundantly each year. Songbirds and squirrels have cleaned up the fruits by late September so that it has little value as a winter food on these sites.

Viburnum dilatatum Linden viburnum

One planting at Connecticut Hill had nearly 60 per cent survival in 1956. Plants have attained a height of 5 feet and have fruited consistently at least since 1955. Fruits persist until spring, but wildlife use is not known. This species needs to be given further trials to determine whether it has wildlife value.

Viburnum Lantana Wayfaringtree viburnum

Two plantings on Connecticut Hill have varied considerably in growth. One planting in a somewhat sheltered spot attained a maximum height of 6 feet, whereas the second in an exposed site reached only 20 inches and was in poor condition. Flowering and fruiting were sparse, so that this plant cannot be recommended for such sites.

Viburnum lentago Nannyberry

Plantings at Partridge Run were slow to grow and did not start to fruit well until after 1950. After 20 years plants were tree-like and 8 to 10 feet in height. They controlled the planting site well an

produced fruits regularly that persisted until the middle of winter or even early spring. As a tall shrub on woodland margins, nannyberry has much to recommend it. Selected forms are known which fruit profusely each year and are being grown from seed for further trial.

Viburnum opulus European cranberrybush viburnum
Viburnum trilobum American cranberrybush viburnum

These two almost identical species have grown fairly well in plantings in many areas in New York, reaching heights of 6 to 8 feet. Fruiting is quite constant, and considerable wildlife use is known. The European species is distinguishable by its susceptibility to leaf rolling aphids and its bitter fruits that persist until April or May when waxwings and catbirds consume the remnants. The American species can be distinguished by its relative freedom from distorted leaves and its sour but not bitter fruits that are lost, mostly to birds, during the winter. Both grow naturally on cool wet sites and do better when the planting site is at least moist than they do on dry sites.

Viburnum prunifolium Blackhaw viburnum

Plantings at Partridge Run were slow to grow and did not attain control of the site until they were about 10 years old. After 20 years they were 8 to 10 feet tall and tree-like. They produced good crops of fruits annually, but these were usually used by wildlife by late November. This can be used similarly to *V. lentago* for a tall shrub in the woodland border or as part of a travel lane for wildlife.

Viburnum recognitum (dentatum) Arrowwood

Plantings at Partridge Run grew fairly rapidly, dominated the site quickly, and began fruiting before 1950. This species is shrub-like, with many straight, upright stems. Its blue fruits are readily taken by songbirds, so that few remain by October. For this reason, it would seem to have less utility where winter foods are wanted.

Viburnum Wrightii Wright viburnum

A small planting at Connecticut Hill grew very slowly and poorly until 1956. Subsequently it grew somewhat better, reaching a height of 4 to 6 feet, with moderate flowering and fruiting, but the plant seems near the limit of its hardiness. Deer have browsed lightly on this in winter. Under more favorable conditions this species fruits abundantly, and the fruits persist until spring. Use by wildlife is not known, but it may be worthy of further trial.

DISCUSSION

It is recognized that other plantings have been made on better sites and soils throughout the Northeast. Nevertheless the experience gained from the plantings on the Connecticut Hill and Partridge Run Game Management Areas can be applied to planning for wildlife plantings on the several million acres of submarginal and abandoned lands in public and private ownership in New York, as well as on the better, agricultural lands.

Certain species are in regular production, for wildlife and erosion control plantings, at the Painted Post Shrub Nursery, i.e., autumn olive, Tatarian honeysuckle, Toringo crab apple, multiflora rose, purple-osier willow, and American highbush cranberry. When properly planted on suitable sites, each of these can serve a useful purpose.

The following shrubs showed strong tendencies to spread, even on these adverse sites: American and Oriental bittersweet, silky dogwood, gray dogwood, European euonymus, bayberry, American plum, shining sumac, fragrant sumac, and coralberry. Japanese barberry, autumn olive and Tartarian honeysuckle have been observed elsewhere to seed abundantly on sandy soils. For the plants that are useful in New York, great care must be taken to select sites where they can be kept under control. Multiflora rose seems to be at its limit of hardiness in upstate New York on upland sites and has shown little tendency to spread.

The tendency of certain of the crab apples to spread slowly by root suckers, as in the case of the Sargent crab apple, can be a distinct advantage in providing insurance against girdling by mice and cottontail rabbits which might otherwise eliminate the plant.

Certain shrubs were heavily browsed by deer: American and Oriental bittersweet, western sandcherry, American and European mountain ash, and Canada yew (Japanese yew is equally susceptible). Most of the other species listed were at least sampled, while moderate, annual browsing was noted on the crab apples, silky dogwood, red-osier dogwood, certain selections of autumn olive, beach plum, and the two corktrees.

Damage by cottontail rabbits was only slight, since the Connecticut Hill plantings were away from cottontail habitat and those at Partridge Run were made during a prolonged low in the cottontail population. Cottontail damage to young multiflora rose plantings is well known; fortunately, the rose recovers very well from what may be a beneficial pruning. Autumn olive was not seriously damaged by cottontails because of its ability to sprout from the base, and this plant can serve a dual purpose of producing twigs as browse as well as a crop of fruits.

Certain plants are extremely susceptible to disease in the humid Northeast: the western sandcherry and the spreading cotoneaster to fire blight, and American plum to black knot. The two corktrees were consistently caught by May frosts which kept them from growing to flowering size.

Because they retain their fruit until winter, or even spring, certain plants seem to warrant further plantings to determine their usefulness to wildlife as emergency winter foods. The following are the most promising.

Cornelian cherry, and its later-fruiting Japanese counterpart, which grew slowly but which will produce a volume of fruit for fall.

Crataegus, in certain selected individuals or clones, to be increased by grafting onto wild hawthorns.

Autumn olive, and the related cherry elaeagnus, in selected individuals, to provide for an extended fruiting season from the middle of July until early November.

Amur honeysuckle and its variety, to provide late-fall and winter fruits after the other honeysuckles have been stripped by migrating songbirds.

Mistletoe honeysuckle, which ripens its fruits in December.

The crab apples, some of which come true from seed, others of which must be propagated vegetatively as clones, for their persistant fruits lasting even until spring.

Multiflora rose, and other roses, to find forms that will be sufficiently hardy for upland conditions in New York.

European mountain ash, because of its persistent fruits, in comparison to those of the American species which are taken by early fall.

Certain of the viburnums, like the linden viburnum, the European highbush cranberry, nannyberry, black haw and possibly the Wright viburnum, all of which may hold their fruits all winter long. For northern New York where winter hardiness is a problem, arrowwood and the wild raisin should be tried, although their fruit retention is of short duration.

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TOXICITY OF AQUALIN TO FINGERLING BROWN TROUT AND BLUEGILLS

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ABSTRACT

The toxicity of aqualin to fingerling brown trout and bluegills was determined by a procedure approximating the concentration to be expected to result from a single field application under certain conditions. Toxicity curves based on time-concentration relationships are presented. The 24-hour TLm was found to be 0.046 ppm for brown trout and 0.079 ppm for bluegills. Reduced toxicity resulting from increasing size was evident for bluegills, and a correction factor is presented for the size range covered. This effect was not clearly established for brown trout fingerlings. For both test organisms the threshold for mortality was below the concentration recommended for controlling aquatic vegetation.

Aqualin[1] is a stabilized solution of acrolein used in some regions for controlling aquatic vegetation. It is reported to be both hydrolysable and volatile.

Applegate *et al.* (1957) reported that no deaths occurred when rainbow trout, bluegills and sea lampreys were exposed to 5 ppm of acrolein obtained from the Product Development Department of the Shell Oil Co. Their studies were conducted at 55° F., with continuous aeration and for a period of 24 hours. They did not correct their figures on concentration to actual active ingredient, but based them upon the formulation. Aeration would result in rapid removal of acrolein.

C. George Green of the Shell Chemical Co., in a personal communication (1959), stated that field observation and laboratory data indicated that carp and thinfin shad were particularly sensitive, being killed at 1-2 ppm, while black bass, bluegills and lampreys appeared to tolerate up to 5 ppm.

Bond *et al.* (1960) reported a 24-hour TLm for chinook salmon of 0.08 ppm active ingredient at 13° and 20° C. For rainbow trout the 24-hour TLm was near 0.065 ppm. These solutions were aerated and, since this would remove volatile material readily, these reported thresholds are believed to be high.

[1] Aqualin (Shell F98) is a stabilized acrolein (2-propenal) manufactured by the Shell Chemical Co. The authors wish to acknowledge the courtesy of the company in providing the chemicals used in this study.

METHODS

Field application of herbicides or insecticides usually involves the treatment of an area only once, at a specified concentration. If repeat applications are necessary, they are usually applied only after the lapse of considerable time. Experimental procedures which are designed to maintain a uniform experimental concentration of the toxicant would not satisfactorily duplicate the conditions associated with field treatment.

In field use of acrolein both hydrolysis and a variable amount of loss from volatility would occur. The rate of hydrolysis would depend upon the molar concentration, the temperature and the time. The pH level could also have an effect, but it would be similar in all waters bearing that pH. Therefore, all solutions to be used in a single experiment were mixed at one time and stored at the experimental temperature. The rate of hydrolysis based on time was then assumed to be similar to that which would occur in the field, with the exception of any effect from sunlight.

Losses by volatility are also based on the molar concentration, temperature and time. Turbulence would increase the rate of loss and increasing depth would decrease it. Replication of the depth of lakes and ponds in which the chemical might be used is impossible in the laboratory. A low rate of loss similar to that which might occur in deep water was simulated to a certain extent through a flow-through procedure in which the containers of stock solutions were stoppered and emptied in turn to the experimental jar by replacement with low pressure air. Losses due to volatilization were thus restricted to that to the air in the stock containers and to that taking place in the experimental jars.

While the experiments are listed in terms of the initial concentration, it should be recognized that over a period of several hours or days the concentration can be much less than the initial concentration. The method does allow the changes that occur to correspond in some measure to those that may take place after field applications.

General Procedures and Control

Except for the use of a flow-through procedure to maintain the oxygen and to prevent excessive loss by volatilization, and except for acclimatizing the fish to an increase of 6° F. for a minimum period of only 4 to 5 days, the basic procedures followed those recommended by Doudoroff *et al.* (1951). The death of each individual fish was recorded and used to produce a toxicity curve in which the logarithmic mean of time to death is plotted for each concentration.

The space available for storage of test solutions was limited, and

a compromise on the usual procedure of this laboratory in respect to rate of flow and size of container had to be made. A 2-gallon container was selected, which allowed for the introduction of approximately 1 gallon every 4 hours at a 2-liter-per-hour rate of flow and about 1 gallon per fish over a 24-hour period. The flow was metered through a Rotameter flowmeter.

The constant-temperature tanks described by Burdick *et al.* (1958) were used for storing the test solution and the experimental jar. The tendency of the solution to increase in temperature during passage through the flowmeter was corrected by passing the liquid through a series of glass tubes immersed in the temperature tank before introduction to the experimental jar.

Oxygen was determined periodically by a modification of the iodized alkaline-iodide sample blank procedure recommended by Ellis *et al.* (1946). In only one experiment was it found to fall below 8.0 ppm, in this case to 7.7 ppm.

Temperature was thermostatically controlled and recorded by a Negretti-Zambra thermometer for the experimental tank, and by a Taylor thermometer for the tank used to hold stock solutions. Temperatures did not fluctuate more than ½° F. from the 60° F. temperature at which the studies were conducted.

Controls were used to verify that the fish would survive longer under the experimental conditions than was needed for completing the tests at the concentrations used. No loss occurred in any control. Neither was there any loss in the stock fish supply during the course of the complete study.

Rome Hatchery springwater was used as a carrier for the chemical. The analysis of this water has been reported previously (Burdick *et al.*, 1954).

Initially the concentrations were not based on the weight of active ingredient, but they have been recalculated and are now so presented.

Statistical Treatment

Time to death, expressed in minutes, follows a logarithmic distribution, so logarithmic means were computed and used in place of arithmetic means. Data are presented in tabular form and include the mean length and range of lengths, range of the times to death, the antilog of the mean time for death and the range of the standard deviation and standard error of the mean expressed in minutes. The antilogs of the deviations from the mean logs are unequal, requiring the use of ranges.

The effect of size (length) on the time to death was calculated

for each concentration and compared for each species used. The mean length at each concentration was used to separate the fish into a larger and a smaller size group at that concentration. The logarithmic mean time of death was computed for each group. That for the smaller size group was subtracted from that for the larger, and the logarithmic mean of the two size groups was used to calculate the percentage variation of difference of the group means. This was then divided by the difference between the mean lengths of the two groups to give a rate of percentage increase or decrease per millimeter.

TOXICITY TO BROWN TROUT

Fingerling brown trout (*Salmo trutta*) from the Rome Hatchery were taken to the laboratory and acclimatized, and experimentation was started 86 days from the first feeding. This lot of fish was used to determine the toxicity of acrolein for a further period of 108 days.

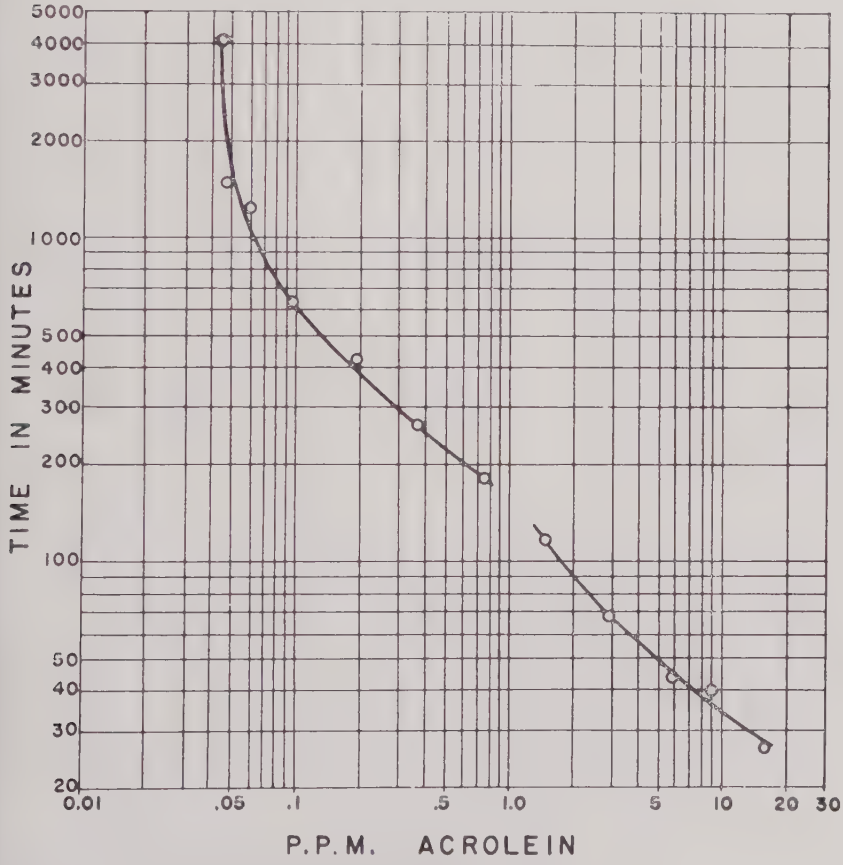

Figure 1. Toxicity of aqualin (acrolein) to brown trout.

Table 1. Toxicity of Aqualin to Brown Trout Fingerlings in Rome Hatchery Springwater at 60° F.*

Number of fish	Mean length (millimeters)	Range of lengths (millimeters)	Aqualin concentration as active ingredient (ppm)	Range of time to death (minutes)	Antilog of mean log. of time to death minutes)	Range of standard deviation of mean log. of time to death (minutes)	Range of standard error of mean log. of time to death (minutes)
20	51.4	43–61	16.0	15– 39	26.0	21.0– 32.2	24.8– 27.3
20	48.9	40–56	9.0	30– 53	39.5	32.9– 47.0	37.8– 40.9
20	62.0	47–78	6.0	28– 61	42.8	34.8– 52.6	40.9– 44.8
20	65.5	47–80	3.0	34– 92	66.9	51.8– 86.4	63.1– 70.8
20	58.5	49–72	1.5	76– 138	115.2	97.9– 135.5	111.1– 119.4
20	55.3	42–72	0.75	107– 248	180.1	142.4– 227.7	170.9– 189.9
20	57.3	46–78	0.37	176– 365	260.3	220.4– 307.6	250.8– 270.2
20	60.0	49–70	0.19	354– 453	417.4	387.8– 440.3	410.6– 424.3
20	60.7	50–78	0.094	490– 937	631.8	537.1– 743.1	609.2– 655.1
20	49.6	40–58	0.060	990–1610	1245	1071 –1448	1204 –1288
20	58.7	45–68	0.047	1162–2087	1487	1231 –1796	1425 –1551
10	60.4	53–68	0.045	1003–5151	4102	2161 –6814	3491 –4819

* Flow-through at 2 liters per hour per 2-gallon container.

During this period the size of fish used ranged from a minimum of 40 millimeters to a maximum of 80 millimeters. Except for the 0.045 ppm concentration, two sets of 10 fish each were used at each concentration. The data are combined in Table 1. This enabled staggering the tests at a concentration to average out some of the growth differential, as can be seen from the table. A high range in size was considered preferable to using several different lots of fish of more nearly the same size and age from first feeding. This choice was required by the limited facilities for conducting flow-through studies.

In assessing the effect of length, eight positive rates ranging from 0.009 to 0.92 per cent and four negative rates ranging from —0.012 to —0.80 per cent were found to occur. This does not indicate a consistent effect for size, and it is concluded that at least in these size ranges the effect of size is too small to counteract the experimental variation.

The data are plotted in Figure 1. A doubly inflected curve is produced, which indicates a toxicity of the vehicle, or the stabilizer within a part of the range tested. It is believed that in this case it was due to the stabilizer.

A combination of two toxic compounds, as well as the fact that the procedure used in these studies produces a continually decreasing concentration with time, does not permit derivation of the threshold, the minimum time for death, or the equation of the toxicity curve as described by Burdick (1957). The 24-hour TLm for this species was found to be equivalent to that produced by an initial concentration of 0.046 ppm.

TOXICITY TO BLUEGILLS

Bluegills (*Lepomis machrochirus*) from a private pond were acclimatized to Rome Hatchery springwater and to temperature. These fish ranged in size from 23 to 68 millimeters, and the average size of the 10 fish used at each concentration varied from 26.2 millimeters to 32.7 millimeters, except that at the 0.18 ppm concentration it was 47.1 millimeters. The 0.077 ppm concentration produced only a 40 per cent mortality in 3.883 minutes. Although this is approximate and the true figure would be larger for the median toxicity, it was used in computing the curve. Exhaustion of the solution required termination at this time.

The data are presented in Table 2, and the curve of toxicity is plotted in Figure 2. A doubly inflected curve similar to that which was found for brown trout is produced. The 24-hour TLm was found to be 0.079 ppm.

The comparisons for the effect of length were all positive and averaged 0.33 per cent per millimeter. It was concluded that in the range of sizes of this species, increase in length resulted in an increased

Table 2. Toxicity of Aqualin to Bluegill Fingerlings in Rome Hatchery Springwater at 60° F.*

Number of fish	Mean length (millimeters)	Range of lengths (millimeters)	Aqualin concentration as active ingredient (ppm)	Range of time to death (minutes)	Antilog of mean log. of time to death (minutes)	Range of standard deviation of mean log. of time to death (minutes)	Range of standard error of mean log. of time to death (minutes)	Correction of time for death to a 30-millimeter length §
10	28.1	23–33	7.04	52– 76	63.7	57.4– 70.7	61.6– 65.8	65.4
10	28.5	25–34	3.52	61– 145	107.0	85.8– 133.3	99.8– 114.7	109.5
10	29.7	24–39	1.76	145– 199	166.4	149.6– 185.1	157.3– 172.1	167.3
10	31.1	25–39	0.88	168– 233	201.7	180.2– 225.9	191.7– 209.1	193.0
10	32.7	27–40	0.44	254– 341	291.2	262.5– 323.0	281.8– 300.9	277.8
10	47.1	30–68	0.18	490– 640	561.6	515.8– 611.4	576.7– 574.9	392.5
10	31.9	25–55	0.088	822–2175†	1181 ‡	831.8–1676 ‡	1031 –1318 ‡	1133
10	26.2	25–28	0.077	1174–1431°	<3883 •	..	..	<4397

* Flow-through at 2 to 4 liters per hour per 2-gallon container.
§ Based on average increase of log. of 0.33 per cent per millimeter.
† For 90 per cent mortality only.
‡ Computed on central 80 per cent of data.
° For 40 per cent mortality only.
• Termination time used, median can be assumed to exceed this figure.

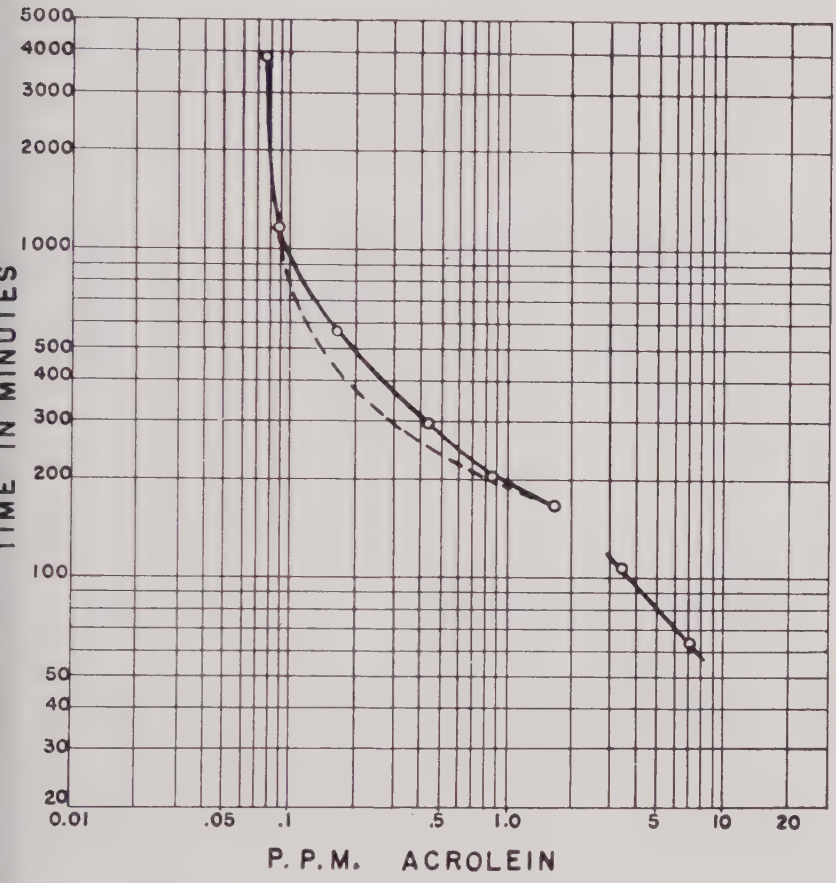

Figure 2. Toxicity of aqualin (acrolein) to bluegills.

resistance to the chemical as shown by time to death. The data were recomputed for an average length of 300 millimeters, and the corrected curve is presented as a dotted line where it deviates from the originally plotted data.

CONCLUSIONS

Aqualin was demonstrated to be toxic to fingerling brown trout and bluegills at concentrations below those recommended for controlling aquatic vegetation.

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DEER USE OF A COMMERCIAL CLEAR-CUT AREA

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ABSTRACT

Deer use was compared on two 1,000-acre areas of forest land in the central Adirondack region in 1961–62. One had been logged by the commercial clear-cut method between 1913 and 1950, mostly after 1946. The other was almost completely covered with old-growth timber similar to that which had been present on the cut area before it was logged. Data were gathered by track counts, pellet counts and a strip census. They indicated that during the severe weather of midwinter deer moved into the uncut area because of the shelter it afforded and deer use was greater there, but that prior to and after this time it was greater on the cut area where food was more plentiful.

Northern New York, especially the Adirondack region, is heavily forested. It is desirable that this land be managed for maximum benefit of the people of the State. The type of management that is ultimately developed will influence the wildlife populations that inhabit the area. In the past most timber cutting in this region has been some variation of the selection system, whether it was of a single-tree or of a group-selection nature. Within the last few years there has been a gradual trend among some operators away from the selection system toward a clear-cut system for reproducing forest stands. If this continues, forest managers in the future will need to know the effects of this type of cutting on wildlife. This study was undertaken to evaluate the effect of the commercial clear-cut method[1] on the use of such a cutover area by white-tailed deer (*Odocoileus virginianus*). The work was done during the winter of 1961–62 and the following spring and summer, while the author was a student in the Department of Forest Zoology at Syracuse University.

THE STUDY AREA

A sizable tract was desirable for the investigation because smaller areas exhibit an "edge effect" that is difficult to interpret and evaluate. Suitable conditions were available on the Archer and Anna Huntington Wildlife Forest[2], and two 1,000-acre areas were selected. The Huntington Forest consists of about 15,000 acres of northern hardwood, hardwood conifer, and spruce flat forests, with scattered spruce swamps and open areas; there are also a number of small lakes and ponds. Climate, topography, soils, vegetation and wildlife are typical of central Adirondack conditions in general.

One of the areas selected (hereafter referred to as the cut area)

[1] Removing all merchantable hardwoods over 14 inches dbh. and all merchantable softwoods over 12 inches dbh.

[2] A property of the State University College of Forestry at Syracuse University and located mostly in Essex County near the village of Newcomb.

had been logged by the commercial clear-cut method between 1943 and 1950, mostly after 1946. Forest types represented were: northern hardwood, 34 per cent; hardwood conifer, 36 per cent; spruce flat, 19 per cent; and spruce swamps and clearings, 11 per cent.

The other area, used as a control, had been untouched in recent time by forest operations. It was almost completely covered with old-growth timber similar to that which had been present on the cut area before it was logged. Forest types were: northern hardwood, 52 per cent; hardwood conifer, 41 per cent; swamps and clearings, 7 per cent; and spruce flat, less than 1 per cent.

METHODS

Data on the relative deer use of the two areas were gathered by three methods: winter track counts, pellet counts, and a strip census.

Track counts were made at the same time on both areas, once each in January, February and March. The observer traversed a predetermined route which consisted of a series of consecutive and continuous units 50 feet long by 4 feet wide. The routes were established in an unbiased fashion. All forest types were sampled, and in each case the proportion represented in the route was within 5 per cent of the proportion for that type on the entire area. The route on each area consisted of 6 miles or 648 units. All recognizable deer tracks were recorded according to unit.

Winter and spring deer pellet groups were counted on plots 132 feet long by 8 feet wide (0.024 acre). On each area 80 plots were sampled in the northern hardwood forest type and 80 in the hardwood conifer type. In addition, in the spruce flat type, 40 plots were sampled on the cut area and 10 on the uncut area. Where a type was large enough, the plots were laid out in a continuous linear series. Differentiating winter from spring pellets was not difficult, and rapid decomposition was not a problem. Patric and Bernhardt (1960) also found that winter pellets persisted for long periods in Adirondack forests.

A strip census was also used to estimate the relative abundance of deer on the study areas. On each the observer traversed on foot a 6-mile route. The routes were established in an unbiased manner, and the representation of forest types in them was closely similar in each case to their proportions on the respective areas. Each area was censused 14 times during late spring and summer. All deer seen or heard were recorded.

RESULTS

The results of the study are presented according to the three types of data recorded.

Track Counts

For each area, the three traverses of the 6-mile route involved potential observations on a total of 1,944 units. Deer tracks were found on 181 units (9 per cent) on the cut area and on 316 units (16 per cent) on the uncut area. The greater frequency on the uncut area was significant (chi-square = 36.66 with 1 degree of freedom) and was considered to reflect a comparably greater degree of deer use during the winter.

On the cut area 26 per cent of the tracks were in the northern hardwood forest type, 56 per cent were in the hardwood conifer type, and 18 per cent were in the spruce flat type; on the uncut area the proportions were 21 per cent, 78 per cent and 1 per cent, respectively. On both areas deer used the hardwood conifer type to a greater extent than other types, although on the cut area the proportion of tracks in this type was lowered by the presence of more spruce flat.

Pellet Counts

Pellet-count records for the three major forest types on each area are summarized in Table 1. More than twice as many pellet groups

Table 1. Number of Deer-pellet Groups per Acre in Cut and Uncut Forest Areas*

Forest types	Cut area		Uncut area	
	Winter	Spring	Winter	Spring
Spruce flat	144	22	37	4
Hardwood conifer	85	13	47	9
Northern hardwood	45	8	27	2
Total	274	43	111	15
Mean	91	14	37	5

* On both areas, the number of plots in each forest type was the same except for the spruce flat (see text); data for the latter were weighted to facilitate direct comparison with those for the other types.

per acre were recorded on the cut area as on the uncut area for both winter and spring periods. The number of pellet groups per acre on the cut area was also greater for each of the forest types.

On both areas, pellet groups were least frequent in the northern hardwood type. They were most frequent in the spruce flat type on the cut area and in the hardwood conifer type on the uncut area. It should be noted, however, that spruce flat stands were much less extensive on the uncut area than on the cut area.

Strip Census

Data from the strip census indicated that from late May to early September deer were twice as numerous on the cut area as on the uncut area. On both areas deer were encountered most frequently in the northern hardwood type. Of 17 observations on the uncut area, 11 were in northern hardwood stands and six in hardwood conifer stands. Of 33 observations on the cut area, 26 were in northern hardwood stands, five in hardwood conifer stands, and two in red spruce stands. It is not known whether deer were actually more numerous in the northern hardwood type at this time, or whether they were just easier to see there.

DISCUSSION

The track counts made during January, February and March showed deer to have been more abundant on the uncut area at that time than on the cut area. On the other hand, pellet groups were recorded more frequently on the cut area. The explanation seems to lie in the seasonal behavior of the deer.

Winter pellet deposition occurs from about November 1 to April 21. This period represents the average interval between the end of leaf fall in autumn and the emergence of herbaceous vegetation in the spring. But severe weather conditions exist during only part of this nearly 6-month period, at most for 2½ months and usually less. It is believed that during the severe weather of midwinter deer moved into the uncut area because of the shelter it afforded and deer use was greater there, but that prior to and after this time it was greater on the cut area where food was more plentiful. Such a shift in deer use would account for the greater frequency of tracks on the uncut area during January, February and March despite the greater numbers of pellets on the cut area. This illustrates the value of using supplementary information, such as track counts, in interpreting winter pellet count data.

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SUBMERGENCE OF BROWN BULLHEADS IN BOTTOM SEDIMENTS[1]

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ABSTRACT

Under laboratory conditions brown bullheads buried themselves in lake bottom sediments at temperatures ranging from 32° to 65° F. At water temperatures of 46° F. and above the mouth could always be seen above the mud or in a funnel just below the surface, and breathing was more or less continuous. At 43° F. and below sediment often covered the mouth for hours. It is possible that the filtering action of sediments on poisons would make eradication of buried fish difficult. Brown bullheads remained active at 32° F. as long as oxygen was available, but they succumbed to freezing.

Eradication of brown bullheads (*Ameiurus nebulosus*) from lakes during reclamation operations is often prevented by the survival of a few fish which then produce an abundance of young. Conjecture about the reasons for such survival has usually centered around the probability that bullheads bury themselves in the bottom sediments of lakes and thereby escape the effects of rotenone.

Information regarding submergence of bullheads has been largely hearsay, although occasional chance observations have been made of bullheads with their heads buried. In one instance known to the author, foot-long fish were found alive and with only their tails sticking vertically out of the bottom.[2] In this case the water was only a few inches deep and covered with an inch-thick layer of clear new ice, and the water temperature was presumably 32° F. or just above. In another situation medium-sized bullheads were observed with their heads buried in the sediments surrounding a spring.[3] Scattered reports of this type are common, but actual knowledge of bullhead activities in relation to bottom sediments is very meagre. This fact, plus questions concerning chemical reclamation work, led to a series of observations at the Fish Laboratory at Livingston Manor (N. Y.).

METHODS

The majority of observations were made in glass-fronted, 350-gallon tanks, 5 feet long by 3 feet wide and 3 feet high. The tanks were brightly lit by overhead white lights, and a flashlight was also used. Whether or not the lights influenced the activities of the bullheads is a moot point; certainly they were necessary. Temperatures,

[1] A contribution of Federal Aid in Fish and Wildlife Restoration Project F-9-R.
[2] Thomas Jesuta, Liberty, N. Y., personal communication, 1963.
[3] J. C. Miller, Pennsylvania Fish Commission, personal communication, 1963.

aeration, water flows, and sizes and numbers of fish were varied as desired, and at all times a 6-inch layer of lake bottom sediments was present.

Observations in the tanks were made only when water temperatures were between 47° and 65° F. Above the upper figure the water became so turbid from increased activities of the bullheads that accurate observations could not be made. The lower limit was the temperature of the spring water. The tanks could be accurately heated but not cooled.

Therefore, observations at temperatures between 32° and 47° F. were made outdoors or in a refrigerator where one limited experiment was carried out at a controlled temperature of 32° F. For the outdoor work a large steel tub was submerged in a pond with the edge above water but with 25 1-inch holes cut around the sides to allow constant inflow and outflow of water. Six inches of lake bottom sediments were placed in the bottom.

The method of observation was to sit in front of the tanks and watch the fish. At higher temperatures activity was frequent if not constant, and bullheads were often observed going into or emerging from the mud. At lower temperatures activity was infrequent and, although fish did occasionally swim about, observations were generally limited to noting their position and breathing activities. Except for breathing rates which were recorded by stop watch, activities of the bullheads were largely unmeasured.

MANNER OF SUBMERGING IN MUD

As many as 12 brown bullheads ranging from 4 to 10 inches in length were under observation at one time. Some preferred to remain partially hidden behind the standpipe in the rear corner of the tank and never buried themselves in the bottom sediment. Others made a practice of doing so and were observed entering or emerging from the bottom sediment many times.

The sediment largely consisted of organic ooze together with some silt and dead leaf material. The fish buried themselves only in the soft material wherever it might be in the tank, and no individual fish reentered at the spot from which it had just previously emerged.

Bullheads buried themselves by thrusting with the head in a strong swimming motion. The fish, which may have been meandering leisurely over the surface of the mud, quickly tilted the body to an almost vertical position and drove its entire body into the sediment with a few vigorous movements. This happened only when the material was soft; leafy material was rarely penetrated. Spots for burial were apparently picked at random.

If resistant material was encountered or the body only half buried, the head was withdrawn and another attempt was made elsewhere. Occasionally, fish were observed to make a dozen or more attempts over a period of several minutes before successful burial was achieved. After burial the body was covered with from a fraction of an inch to 2 inches of sediment, the long axis of the body was horizontal or tilted slightly up toward the mouth, and the lateral axis was canted at an angle so that one gill more or less pointed up and the other down. The final position was achieved in one of two ways.

Most often the fish drove down and then horizontally to a completely buried position at which point it rested for a moment. The next objective, if it may be called that, was to bring the buried mouth into direct contact with the free water above the surface of the mud. This was often accomplished by a vigorous upward shifting of the body until the lips pierced the surface of the mud. In this position a barbel or two, or rarely an eye, might be exposed. On the other hand (and almost always at temperatures below 47° F.), a horizontally buried fish often made contact with the free water by sucking in the inch or two of sediment covering its mouth and expelling the material in geyser fashion from the uppermost gill. In this way a small funnel was formed over the mouth and the material from the funnel was deposited over the gill in a volcano-like mound so that an open passage of water extended from the gill to the top of the mound.

A second method of burial was sometimes employed by more energetic or less conservative fish. In this case the fish came to rest with its mouth at the surface of the mud in one vigorous series of movements—down, horizontal and up. Occasionally one of these fish would overshoot the mark and come to rest with its head protruding from the mud. This position was never suitable and, since the fish are incapable of backing into the mud, was always abandoned.

Buried fish may or may not give evidence of their intention to emerge from the mud by a few preliminary movements. Emergence is awkward, and the result is a momentarily disoriented, mud covered fish. The mud usually adheres to the fish for several minutes.

CONTACT OF THE MOUTH WITH FREE WATER

At temperatures of 47° F. and above, buried bullheads whose mouths became artificially covered with sediment invariably shifted their positions upward until the mouth was once again in contact with free water. The upward shifting took place after a period of from several seconds to 15 minutes following the time the mouth was covered. Repeated coverings were always followed by change of position at shorter intervals (as if the fish were getting out of breath) until the fish finally burst from the mud and swam away. It is con-

cluded, therefore, that the mouth must be in contact with free water, at least at temperatures of 47° F. and above.

At these temperatures the funnel over the mouth (present only if the mouth was well below the surface of the mud) often became the momentary recipient of loose sediment stirred up by the activities of other fish. This debris was immediately sucked into the mouth and passed through the uppermost gill. In this way, the funnel was always kept free and open, and the mouth was always in direct contact with free water. On the other hand, the water passage over the gill usually became filled with flocculent material which pulsated as breathing took place.

RELATIONSHIP OF MOUTH TO FREE WATER AT TEMPERATURES OF 47° F. AND BELOW

Observations of bullheads at temperatures of 47° F. and below took place outdoors with the use of the tub already described. At these temperatures the fish were rarely seen swimming actively, and no attempt was made to observe actual entrance into or emergence from the mud. It was possible, however, to account for each fish during several weeks when one to several observations were made each day. During this period temperatures fluctuated between 46° and 32° F. but exhibited a downward trend.

Hundreds of observations were made, and from these it appeared that the fish buried themselves more deeply than they had in the tank at higher temperatures. Only rarely did the mouth pierce the surface of the mud, but in almost all cases a mouth funnel and gill passage were present. Many times the mouth could be seen at the bottom of the funnel and breathing noted. Once at 46° F., often between 46° and 37° F., and always between 37° and 32° F. the mouth funnel was filled with sediment. Weak pulsation of the material filling the passage over the gill showed that breathing was more or less continuous at these low temperatures. Obviously the fish's metabolism was low enough to allow weak breathing through a 1- to 2-inch filter of bottom sediments. At a temperature of 39° F. two fish were found buried beneath 2 inches of sediment without the presence of a funnel over the mouth or a passage over the gill. There they remained for hours and were active after being dug out. It is assumed that they were breathing, in this case through 2 inches of organic bottom ooze.

BREATHING RATES

Breathing was more or less continuous at all temperatures but was so weak below 37° F. that the pulsations could not be counted. At any temperature above 43° F., steady pulsations were often spaced between single or several more violent jaw movements as if the fish

TABLE 1. RATE OF BREATHING OF BROWN BULLHEADS SUBMERGED IN BOTTOM SEDIMENTS WITH MOUTHS SHOWING

Temperature in degrees F.	Rate per minute	Number of observations
37	18	1
39	10	1
40	15	1
42	20 *	1
43	11–18 *	2
44	17–21 *	2
47	15–28	7
48	30	1
50	37	1
54	21–65	10
57	53	1
62	53–73	6
65	67	1

* Observed not breathing for varying periods ranging up to 10 minutes.

were gasping or gulping water. Breathing pulsations varied from 10 to 73 per minute and increased as the temperature rose (Table 1).

TIME FISH REMAINED BURIED

Bullheads were observed to remain buried for several hours (maximum of 6) at a time at a temperature of 65° F. without changing position. At 47° F. and below individual fish remained in position for over 24 hours. Even at a temperature of 32° F., however, the fish occasionally emerged from the mud and swam actively although somewhat sluggishly about. But in general it can be said that they buried themselves less often at higher temperatures and for shorter intervals. At a temperature of 47° F. it was possible to bring them out of the mud by violent pounding on the tank or by raising the water (not the mud) temperatures 3 or 4 degrees. In both instances emergence was leisurely. Electric shock forced them out instantly and violently.

REACTION TO EXTREME CONDITIONS

Limited tests under adverse conditions indicated that bullheads are not as tenacious of life as is popularly thought.

Three 8-inch fish were placed in the bottom of a plastic pail and covered with 8 inches of organic ooze. In half an hour they worked themselves to the top of the pail where, still covered with ooze, they died in less than an hour. The mud temperature was 50° to 53° F.

Two 8-inch bullheads were placed on top of a pail of organic ooze and were actually half submerged in water. They died in 10 hours at a temperature of 50° F.

Three 8-inch bullheads were covered with a pail of ooze and worked their way to the top in half an hour. The temperature was maintained at 32° F. Ice formed above but not below two of the fish which died in less than 2 days. The third fish remained at the top for a week, without visible movement and without contact with ice. This fish quickly became active when placed in water of 32° F.

Several fish were subjected to freezing in mud and water and quickly succumbed.

Six 4-inch fish were placed in water at 32° F. where they remained active until ice cover caused a lowering of the oxygen content of the water. Three died, but three became active when the oxygen content was raised from less than 1 ppm to 10 ppm.

RELATIONSHIP TO POISONING

It appears that a certain proportion of the brown bullhead population in a lake will be buried in the bottom sediments at any given moment; the proportion will rise as temperatures fall. These fish may be hard to kill even if a toxic agent reaches the surface of the bottom sediments (and assuming that it maintains its toxicity in the face of turbidity and chemical breakdown at the interface between water and sediment). At temperatures of 47° to 65° F. some bullheads will be in position with the mouth at the bottom of a 1- to 2-inch-deep funnel filled with turbid water. And while in this position it is possible that the weakened poison might pass over only one set of gills. In addition, the body of the fish would be protected by sediment. It is possible that the amount of chemical available to a fish under such circumstances (especially a chemical that detoxifies or deteriorates rapidly) would be too little to have appreciable effect. At temperatures of 46° F. and below the poison might be further filtered and detoxified by a 1- to 2-inch layer of sediment covering the mouth. It should be noted that temperature preferences of bullheads, when there is a choice, are unknown.

EFFECT OF CHANGES IN WINTER WATER LEVELS ON MUSKRAT WEIGHTS AND HARVEST AT THE MONTEZUMA NATIONAL WILDLIFE REFUGE

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ABSTRACT

During the winter of 1961–62 data on muskrat weights, water levels and air temperature were recorded at the Montezuma National Wildlife Refuge. On areas where the water level had been lowered by drainage, subfreezing temperatures resulted in ice formation reaching the bottom as well as in freezing the feed beds, and heavy weight losses occurred. Lesser weight losses occurred on an area where normal water levels were maintained. Reflooding of the drained areas resulted in most of the lost weight being regained. Evidence of disease and parasitic infection was heaviest in muskrats from areas of low water. The possible control of muskrat populations in northern marsh areas through winter drainage is suggested.

During the winter of 1961–62 disease investigations of muskrat (*Ondatra zebethica*) populations were conducted at the Montezuma National Wildlife Refuge in central New York (Friend and Muraschi, 1963). At that time portions of the study area were being drained in an attempt to control populations of carp (*Cyprinus carpio*) within the refuge. This winter drainage, and subsequent reflooding, produced noticeable effects on the muskrat populations being studied.

MATERIALS AND METHODS

The refuge is divided into four areas the water levels of which can be controlled. The largest occupies over 1,200 acres and the smallest about 160 acres. Data were recorded for muskrats trapped on three of these (Figure 1) from December 1961 through March 1962. At the start of trapping operations in December all three areas contained normal water levels for that date (Table 1 and Figure 2). No manipulation of water levels took place on Area A throughout the study period. Area B was drained in early February and was reflooded approximately a month later. Drainage was started on Area C in early December and a minimum water level was reached by late January. The area was not reflooded until late February.

Water levels were recorded on each week day. Maximum and minimum air temperatures were recorded daily by means of a maximum and minimum thermometer.

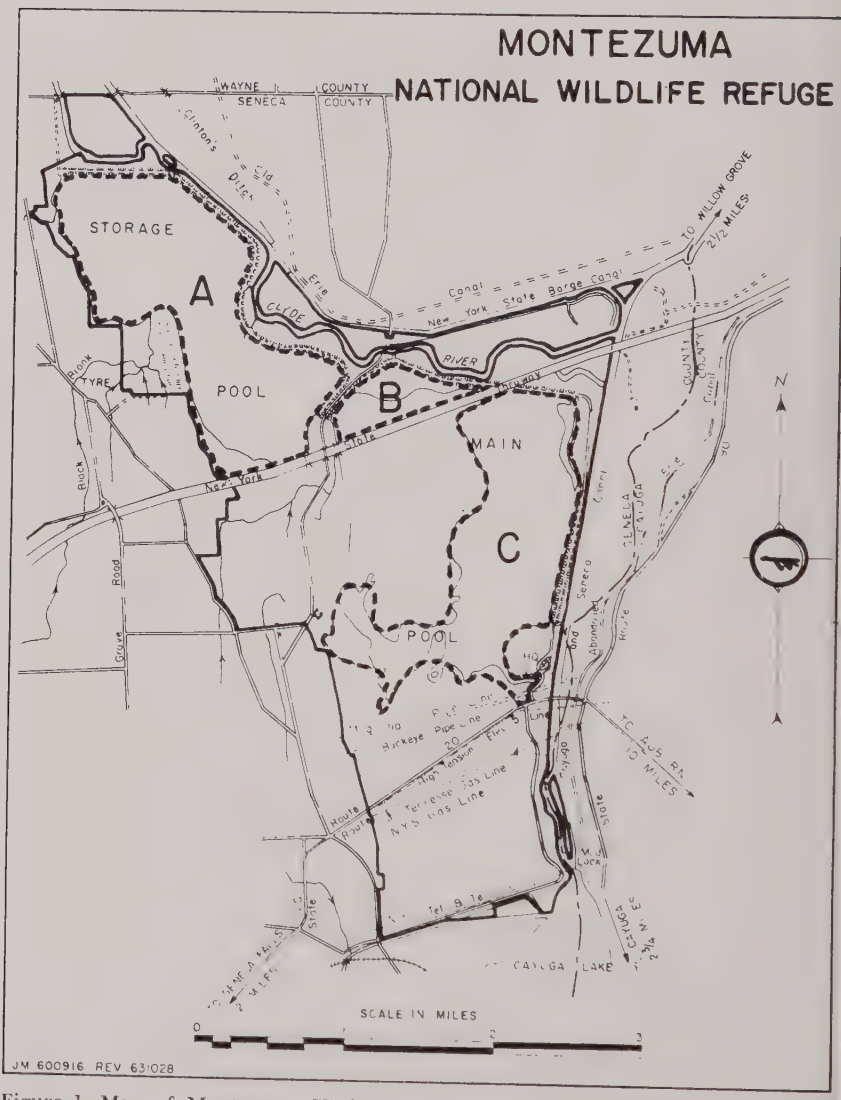

Figure 1. Map of Montezuma National Wildlife Refuge showing location of the areas used in this study.

The sex and weight of all muskrats were recorded by area. In addition, periodic autopsies of a number of muskrats from each area were made. All lesions were noted as were the approximate levels of body and visceral fat present (abundant, medium, scarce).

FINDINGS

Subfreezing temperatures prevailed generally from early December through February and were at their lowest ebb in late January and

TABLE 1. NORMAL DECEMBER-MARCH LEVELS FOR THE STUDY AREA AT THE MONTEZUMA NATIONAL WILDLIFE REFUGE

Area	Average water-gauge reading *	Average water depth §
A	385-1.2	37.2
B	383-1.2	24.0
C	383-1.2	36.0

* In feet and inches above sea level.
§ In inches.

February. Muskrat weights dropped substantially when low water and temperatures well below freezing occurred at the same time (Figure 2). Weight reduction was most pronounced on Area C where the average loss was 34.7 per cent (Table 2). This was more than

TABLE 2. CHANGES IN WINTER WEIGHTS OF MUSKRATS IN RELATION TO HIGH AND LOW WATER LEVELS AT THE MONTEZUMA NATIONAL WILDLIFE REFUGE, 1961–62*

Area	Average weight (ounces)		Weight loss (per cent)	Average weight after reflooding § (ounces)	Lost weight regained (per cent)
	High water	Low water			
A	55 (355)	46 (199)	16.4	52 (215)	66.7
B	50 (76)	37 (9)	26.0	46 (42)	69.2
C	49 (98)	32 (65)	34.7	44 (138)	70.6

* Figures in parentheses represent number of muskrats in sample.
§ Represents reestablishment of normal water levels on Areas B and C; water level on Area A had not been drawn down.

double the apparently normal weight loss on Area A where the water level was not drawn down. Weight reduction on Area C was rapid and closely followed a sharp drop in temperature. By comparison, weight reduction on Area A was quite gradual. Drainage of Area B during late winter was followed by an average weight loss of 26.0 per cent in a short time. When Areas B and C were reflooded the muskrats soon regained much of their lost weight. The period of reflooding coincided with rising temperatures.

The harvest of muskrats was lowest on Area C, being only about 24 per cent of the estimated fall population compared with over 70 per cent for each of the other areas (Table 3).

Table 3. Degree of Harvest and Observed Abnormalities in Muskrats at the Montezuma National Wildlife Refuge, 1961–62

Area	Estimated population *	Harvest		Specimens examined		Specimens exhibiting lesions	
		Number	Per cent	Number	Per cent of catch	Number	Per cent
A	6,125	4,481	73.2	829	18.5	75	9.1
B	2,500	1,853	74.1	283	15.3	24	8.2
C	5,150	1,217	24.2	196	15.7	23	14.3

* Based on house counts and a factor of five muskrats per house (after Alexander, 1956).

Autopsies performed on muskrats trapped revealed numerous instances of lesions within the livers and a lesser number of other lesions. Many liver lesions were suggestive of parasitic infection, and further examination revealed the presence of larval cestodes. Several specimens were sent to the Beltsville Parasitological Laboratory of the U. S. Department of Agriculture where they were identified as *Cysticercus fasciolaris*, the larval stage of *Hydratigera taeniaeformis*. The heaviest incidence of infection was found in muskrats from Area C.

The amount of visible body and visceral fat was found to be very low or absent in the majority of muskrats trapped on Area C. By contrast, muskrats from Area A exhibited heavy body fat and medium to heavy visceral fat throughout the winter.

DISCUSSION

It has been noted that muskrat weights on the Montezuma refuge usually tend to increase until late winter (Dozier, 1945; Alexander and Radway, 1951). At that time, however, weight loss and disappearance of accumulated fat takes place apparently during the process of conditioning for early mating (Dozier, 1950). A trend of increasing weight throughout most of the winter was also noted on the Blackwater National Wildlife Refuge in Maryland (Dozier *et al.*, 1948).

Even though water levels on Area C were at their minimum from about the first of January until mid-February, muskrat weights continue to increase throughout the month of January. The animals

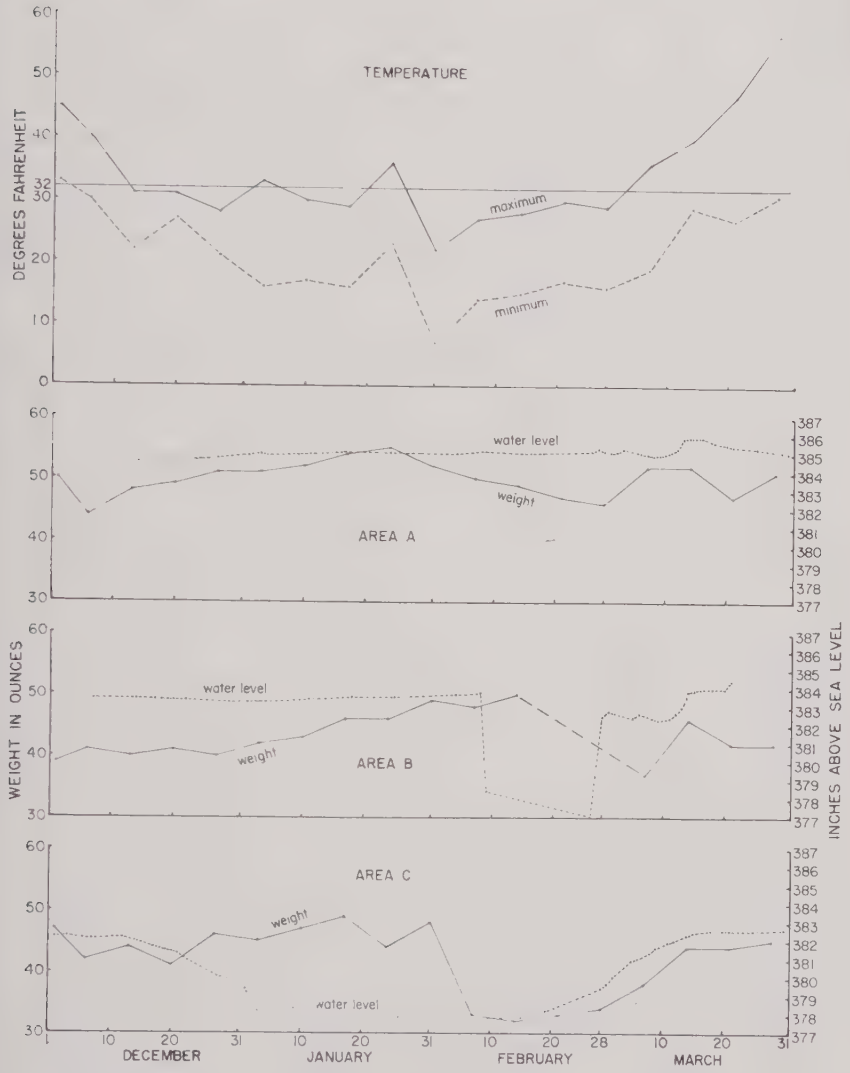

Figure 2. Average weekly temperatures and relation of changes in muskrat weights and water levels on Areas A, B and C at the Montezuma National Wildlife Refuge during winter of 1961-62.

apparently were still able to find sufficient feed to maintain body weight. During late January a sharp decline in daily temperatures occurred (Figure 2) and heavy ice formation took place. The cold was severe enough to freeze the mud bottom on drained areas to a depth of several inches, and it also froze both the feed beds and the approaches to them. The muskrats were then unable to gain access to their food supplies and a sharp drop in weight took place. It

became possible to separate muskrats trapped on this area from those trapped on the other two areas simply by visual observation. These muskrats were coated with mud, probably as a result of their efforts to tunnel to food supplies, and their body and visceral fat was at a very low level or absent.

During late winter Area B was drained, and a similar drop in muskrat weights occurred. By contrast, weights from Area A were only slightly lower during this period in the presence of an adequate water supply (Figure 2).

These data indicate that neither a minimum winter water level nor subfreezing temperatures alone will seriously affect muskrats. In combination however, they may impose severe hardships on a muskrat population by closing routes of travel to feed beds and even freezing sources of food. Bellrose and Low (1943) felt that water-level fluctuation was one of the most important environmental factors affecting muskrat populations in the Illinois River valley. In the present study the effect of favorable water levels was further illustrated by the rapid increase in weights when the levels were returned to normal on the drained areas.

Even though the surviving muskrats regained a large proportion of their lost weight after the areas were reflooded, it was evident that prolonged winter drainage resulted in a lowered population. This was especially true on Area C where trapping operations resulted in a catch of only 24 per cent of the estimated fall population compared with 73 per cent and 74 per cent for the other areas (Table 3). Trapping conditions on Area C were more unfavorable than on either Area A or Area B. As a result, trapping effort was somewhat lighter because fewer traps could be set and checked each day. However, since trapping regulations on the refuge allowed setting traps in the houses to ensure a heavy harvest, it is felt that a fair proportion of the actual population present at the time was trapped.

The low catch on Area C probably reflected a population substantially reduced from that present at time of census. Most of this loss very likely resulted from a combination of starvation, disease and predation. Population loss due to movement from the area was felt to be low. Errington (1963) found little evidence of winter movement of muskrats in northern latitudes of North America. He also found that, under extreme conditions of drought and freeze-out, some muskrats may leave an area while others will not. Some movement from Area C was evidenced by the carcasses of a few animals killed on roads. But, if movement off the area had been heavy, the number of road-kills should have been much greater because Area C is bordered on both the north and south by heavily traveled major highways (Figure 1). Movement east or west was unlikely as the

topography was rolling for some distance, while flat marshland lay north and south of the area.

Frequent observations were made of muskrat feeding in fields and along dikes on Area C, but not on Areas A and B. Surface feeding is characteristic during freeze-outs and other undesirable conditions (Errington, 1961: Bellrose and Low, 1943). Vulnerability to predation is greatly increased during such feeding (Errington 1939, 1961). On two occasions red-tailed hawks (*Buteo jamaicensis*) were observed feeding on fresh muskrat carcasses, but in neither instance was the actual kill observed. Surface feeding and movement associated with it contribute to death from exposure to severe cold or freezing wind (Errington, 1939). For these reasons Errington (1961) concluded that in a cold climate individuals remaining in their familiar home range have the better prospect of survival in freeze-out emergencies.

Autopsies revealed a higher incidence of muskrats with lesions suggestive of parasitic infection and disease on Area C than on Areas A or B (Table 3). The severity of infection was usually greater in individuals from this area also.

Based on these observations, it seems possible that muskrat numbers can be materially reduced in northern areas by prolonged winter drainage of marshes. On areas where trapping is either undesirable or ineffective, winter drainage may be a useful tool in managing muskrat populations.

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WILDLIFE ECOLOGY OF A HEAVILY-USED AQUATIC AREA[1]

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ABSTRACT

A study was made of a biotic community at the head of Jamesville Reservoir, an area under heavy, periodic recreational use, to determine seasonal changes in the kinds and numbers of animals present. Systematic sampling, supplemented with visual observations, were used to gather information on the principal organisms in the ecosystem. The animals found in the area were greatly affected by water-level fluctuations in the reservoir. Invertebrates that serve as food for fish, and the fish themselves, were forced to migrate as their habitat dried up. The recreational users of the area appeared to have relatively little effect on the vertebrates.

How does wildlife utilize a man-made water area that is under heavy, periodic recreational use? The rapidly expanding population of the State, coupled with more time available for recreation and an increasing interest in the outdoors, is creating greater pressure on existing outdoor recreational areas. In some places the problem may be compounded because various recreational activities are not compatible, for example, fishing versus swimming or boating. To what extent does wildlife use such areas?

In an attempt to find some of the answers to these questions, a study was made at Jamesville Reservoir which lies 6½ miles southeast of Syracuse (N. Y.). The reservoir is a relatively small water area, it is man-made, it supports an active sports fishery, and it is heavily used by swimmers, boaters, and picnickers. The work was done in 1952.

THE STUDY AREA

The physiography of the area around Jamesville Reservoir is typical of the glaciated sections of central New York (Figure 1). Land use practices in the valley are varied. The steeper west slope has somewhat more forest cover than the east slope and valley floor which are largely in dairy farms, with pastures and hay and grain fields. The soils are fertile, well suited for agriculture, and generally calcareous because of the limestone bedrock. The fine-textured soils contribute considerable sediment to the reservoir inlet.

The valley in and around the reservoir has a long history of human habitation that dates well beyond the Colonial period. The

[1] Derived from an M. S. thesis submitted to the Committee on Graduate Studies, State University College of Forestry at Syracuse University. The author extends particular thanks to Dr. Maurice M. Alexander and Prof. Wilford A. Dence for their guidance and for help in the field work.

[2] Present affiliation: U. S. Fish and Wildlife Service, Bureau of Commercial Fisheries Biological Laboratory, Woods Hole, Massachusetts.

Figure 1. Jamesville Reservoir, view to the north in Butternut valley.

history of the reservoir site, from ancient times to the present, has been reviewed by Jensen (1960, 1963). The reservoir itself was formed by damming Butternut Creek in 1874 to augment the water supply in the Middle Division of the Erie Canal during dry periods. The State continues to maintain it as a feeder for the Barge Canal (which replaced the Erie Canal). Although the water flow over the dam spillway is not controlled, water-level measurements are made four times each month to determine the volume in the reservoir.

Water Supply and Characteristics

The 47-square-mile watershed that supplies the reservoir is drained by a number of permanent streams. The principal feeder is Butternut Creek, a fast-flowing stream that varies from 10 to 20 feet wide throughout most of its length. The creek is fed by 31 smaller streams, and from early March to May it is in near-flood condition and occasionally overflows its banks. During this period it is very turbid with silt washed from the valley sides. Silt deposits have formed a sizeable delta at the southern end of the reservoir.

The reservoir has a surface area of 252 acres, an average depth of 16.4 feet and a capacity of 170 million cubic feet of water.[3] The water is extremely hard (total carbonates, 130 to 160 ppm) which is to be expected considering the calcareous nature of the local bedrock and soils. It is well aerated and fertile. Although no extensive limnological survey was made of the entire reservoir, the physical characteristics of the water were determined at one station in October

[3] W. Robinson, N.Y.S. Department of Public Works, personal communication, 1952.

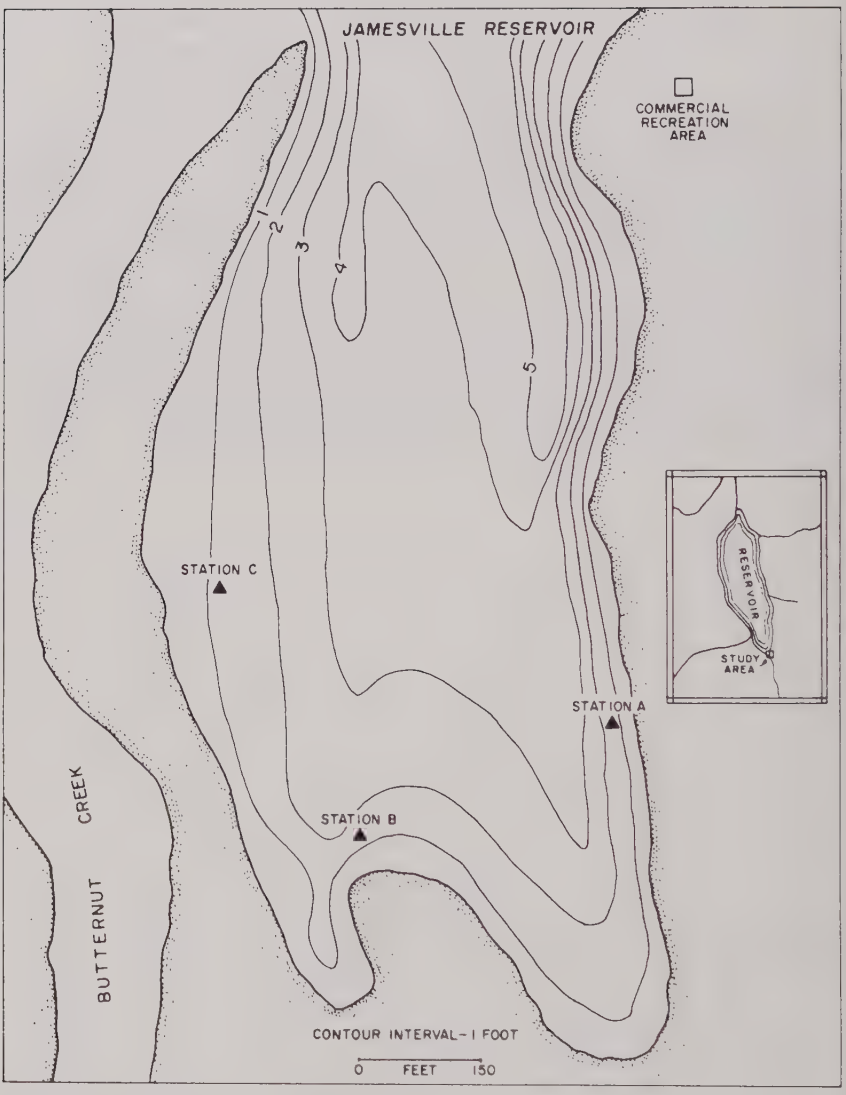

Figure 2. The area where intensive sampling was done.

1951. Water temperatures at the surface and on the bottom (15 feet) varied no more than 1 degree and the other physical factors were uniform. The water temperature was 60° F., oxygen was 10.8 ppm, carbon dioxide was 3.0 ppm, and pH was 7.8.

The reservoir is very popular with local fishermen, many of whom travel more than 10 miles to fish there. Ice fishing, too, is popular in winter when the ice cover is thick enough. At the time of this study, recreational facilities included a large public beach on the

western shore constructed in the early 1950's, that was heavily used during the summer months. In addition to bathers and fishermen who traveled to the reservoir from Syracuse and other nearby communities, there was a large resident population whose year around homes lined most of the eastern and western shores.

Fish and Other Animals

Fishermen reported that at one time many pikeperch were caught in the reservoir, but in 1952 they were only rarely taken. The most frequently caught fish was the yellow perch, many of which weighed 1 to 1½ pounds. The reservoir and the area along its shores were inhabited or visited by many species of birds and mammals. The common species of amphibians and reptiles were present, including bullfrogs, green frogs, salamanders, snapping turtles, and painted turtles.

The Sampling Area

The most intensive sampling was done in the bay at the southern end of the reservoir (Figure 2). This bay was important as a nursery area for several species of fish and as a feeding and shelter area for muskrats and ducks. In addition, it was adjacent to a commercial recreation area, open during the summer season, that at times had as many as 200 people on the grounds.

The bay was bounded on the west by Butternut Creek and on the east by the recreation area and an abandoned pasture. The southern boundary was a level field, probably also an abandoned pasture, that was flooded by the creek each spring. It had a surface area of 16.1 acres, half of which was under water 6 or more months of the year. The average depth of water, under "normal" conditions, was 24 inches. However, during late August and September the water level was lowered considerably (Figure 3).

METHODS

A broad ecological approach was taken in gathering information. The dynamics of the ecosystem represented by the bay were included. Some of the interspecies relationships were determined by food habits studies and estimates of comparative population densities. Seasonal changes in the species composition of the communities within the study area were examined, particularly their relationship to physical changes in the aquatic environment.

A systematic sampling procedure was used to gather information on the ecosystem of the bay. The sampling procedure also made it possible to study the intra-community relationships. Three perma-

Figure 3. Two views from about the same position showing water level in early spring (upper) and in late summer (lower). The dense stand of vegetation in the lower view was common horsetail (*Equisetum arvense*).

nent sampling stations (Figure 2) were established in the littoral zone in places considered typical of the different parts of the bay.

Station A, on the eastern shore, was shaded by large, overhanging willows (*Salix* sp.) and received diffused sunlight until about noon. During the remainder of the day it received direct sunlight. This was the only station underwater throughout the year, the water depths ranging from 39 to 56 inches. In season, aquatic vegetation was dense at this site. The most abundant plants were waterweed (*Anacharis canadensis*), hornwort (*Ceratophyllum demersum*), and water smartweed (*Polygonum amphibium*).

Station B, at the extreme southern end of the bay, was also surrounded by an overstory of willows and received only filtered sunlight throughout the day. This was a shallow-water station with a maximum springtime depth of 10 inches. The water level dropped markedly later in the season, and from about mid-August to early December there was no water although the soil remained quite moist. Cattail (*Typha latifolia*) was common here and attracted muskrats; one small muskrat house and several feeding platforms were nearby. During the early spring chain pickerel spawned in the area around the station.

Station C, on the western side of the bay, was surrounded by dead or dying willows and elms (*Ulmus americana*) and received at least partial sunlight from early morning until early afternoon. This was another shallow-water station. The depth varied from 12 to 24 inches during the year except for the period from early September to early December when this site was dry. Aquatic vegetation around the station was very sparse.

Temporary stations were established in other parts of the bay as needed for specific collections or observations.

Biological observations and collections and water-depth and temperature measurements were made at 7- to 10-day intervals from April through December. Bottom organisms were collected by scraping a fine-mesh dipnet over the substrate in a 1-foot quadrat to gather the top ½ inch of material. The small size of the quadrats left enough undisturbed bottom for subsequent collections. Midwater and surface organisms were collected by drawing the dipnet through the water in a sweeping motion. About 1 cubic foot of water was sampled with each sweep. The dipnet was also used to capture amphibians. At other times a 6-foot minnow seine and a fyke net were used to collect fish, and a few fish were collected by angling.

OBSERVATIONS

Feeding, growth, and reproduction may be used as indices to the manner in which wildlife use an area. The data collected in this study are presented under these and related topics.

Invertebrates

The bottom samples and water-sweep samples indicated the area had a varied invertebrate fauna (Table 1). As might be expected,

Table 1. Numbers of Invertebrates Collected in Bottom Samples and Water-sweep Samples at Jamesville Reservoir

Organism	Station			Total
	A	B	C	
Bottom samples (June–December, 1952)				
Gastropods				
Planorbis	2	6	11	19
Pelecypods				
Musculium	2	7	3	12
Sphaerium	1	..	..	1
Oligochetes				
Tubifex	37	22	54	113
Crustaceans				
Hyalella	9	4	14	27
Cambarus	12	5	..	17
Insects				
Ephemerida *	6	4	..	10
Anisoptera *	34	4	7	45
Zygoptera *	21	..	5	26
Notonecta	6	..	..	6
Tendipes *	99	34	49	182
Chrysops *	..	5	1	6
Water-sweep samples (April–December, 1952)				
Crustaceans				
Hyalella	19	..	..	19
Insects				
Ephemerida *	34	8	2	44
Anisoptera *	11	5	9	25
Zygoptera *	91	4	6	101
Corixa	14	19	20	53
Notonecta	28	16	10	54
Tendipes *	15	..	..	15
Gyrinus	14	10	6	30

* Nymphs and larvae.

the invertebrates were affected most by the fluctuations in the availability of water, as reflected by its depth and temperature (Figures 4 and 5). The changes in numbers and species composition suggest

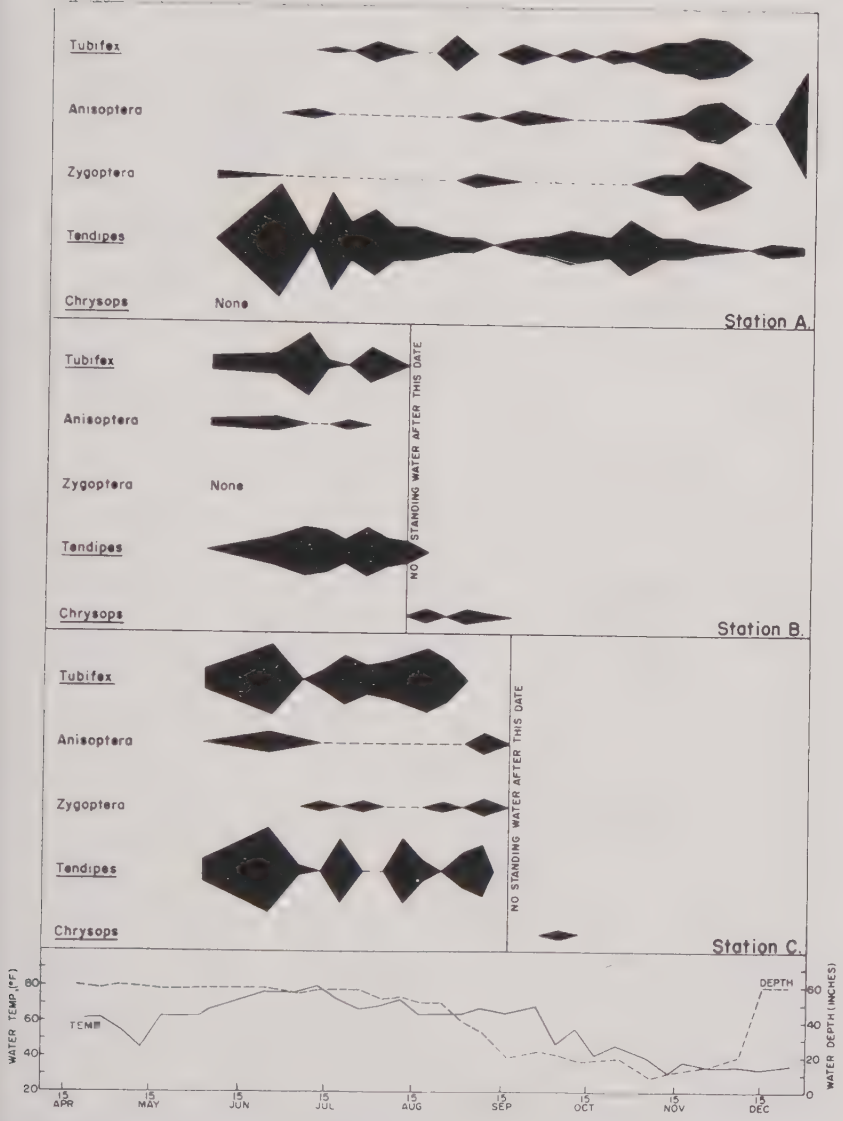

Figure 4. Seasonal changes in the principal bottom invertebrates collected at Stations A, B and C. The trends in water temperature and depth at Station A are shown.

the community periodicity defined by Odum (1959). The abundant damselfly (Zygoptera) nymphs and *Tendipes* larvae were important items in the diets of several species of fish.

Data were available from a series of Ekman dredge samples collected in the reservoir the previous fall (Table 2). They afford a rough comparison between the species composition in the reservoir

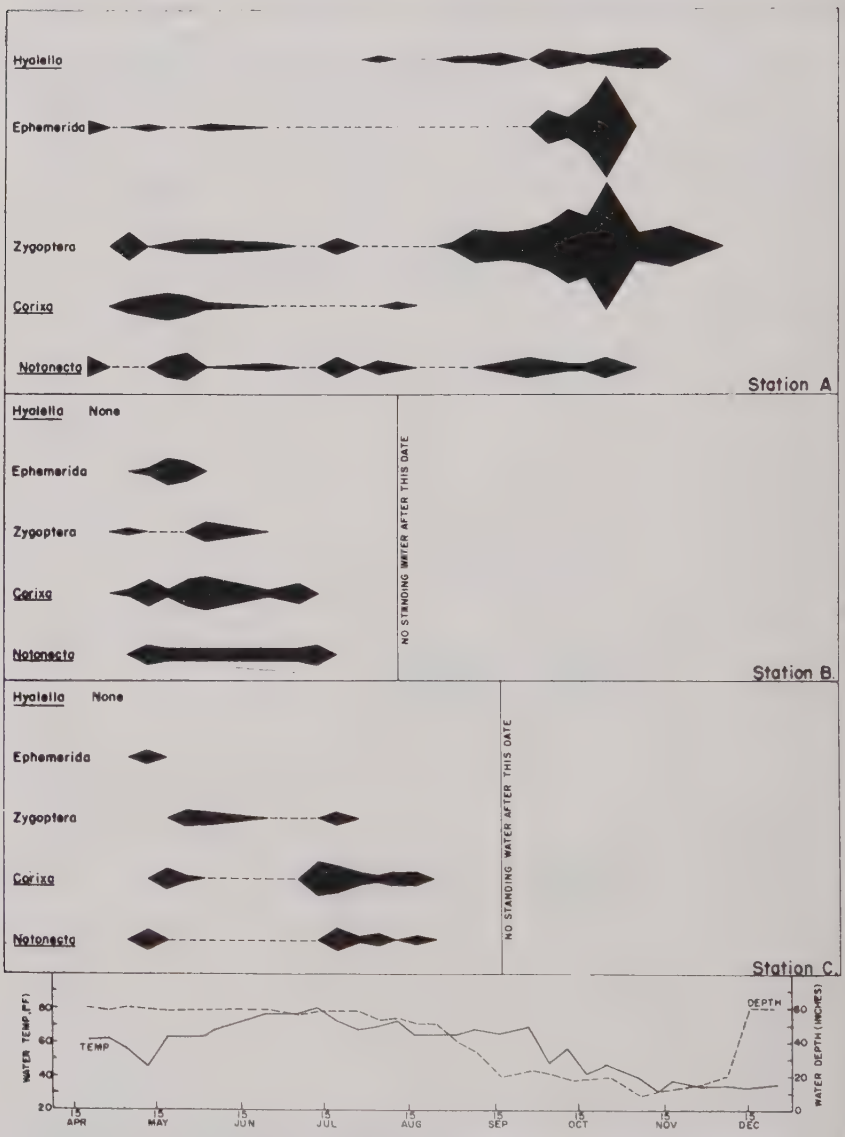

Figure 5. Seasonal changes in the principal midwater and surface invertebrates collected at Stations A, B and C. The trends in water temperature and depth at Station A are shown.

and in the bay. The reservoir samples contained more individual organisms but fewer species.

Vertebrates

Jamesville Reservoir, the land margin around it and the bay at

TABLE 2. BOTTOM INVERTEBRATES COLLECTED IN TWO EKMAN-DREDGE SAMPLES FROM JAMESVILLE RESERVOIR IN OCTOBER 1951

Organism	Depth in feet			Total
	5	10	15	
Gastropods				
Planorbis	2	4	56	62
Oligochetes				
Tubifex	..	..	12	12
Insects				
Anisoptera *	1	3	..	4
Zygoptera *	..	4	..	4
Tendipes *	..	10	143	153

* Nymphs and larvae.

the southern end supported a diverse wildlife population. Forty vertebrate species were collected or observed (Table 3). The greatest variety and the largest number were present during the spring. This was particularly true for some of the fish that used the bay as a spawning and nursery area. Some species remained in the area to rear their young, then left later in the summer. A few lived in the bay throughout the year.

FISH Ten species of fish were collected or observed. Except for pikeperch, the species in the bay were the same as those in the main part of the reservoir. Insufficient specimens were collected for a detailed food habits study, but stomach contents of all specimens were examined and recorded.

Brown bullheads up to 10 inches long were present. Their principal food item was *Tendipes* larvae. The nymphs of dragonflies (Anisoptera) and damselflies were the next most abundant food items. Snail (*Campeloma*), clam (*Musculium*), and crayfish (*Cambarus*) remains were found in most bullhead stomachs. One contained the partially digested fragments of an adult tapeworm, perhaps ingested with other food material.

The food of the chain pickerel varied with the size of the fish. Pickerel less than 6 inches long fed chiefly on dragonfly and damselfly nymphs. Larger pickerel ate vertebrates, mostly fish, including pumpkinseeds, largemouth bass and, in one case, a frog. Pickerel were eagerly sought in the reservoir by fishermen during the summer, but few were caught through the ice in winter.

The yellow perch examined were wholly insectivorous. Mayfly (Ephemerida) and damselfly nymphs were common food items, par-

Table 3. Vertebrates of Jamesville Reservoir Area

Species	Estimated abundance
Fish	
Grass pickerel (*Esox vermiculatus*)	Rare
Chain pickerel (*Esox niger*)	Abundant
Brassy minnow (*Hybognathus hankinsonii*)	Common
Golden shiner (*Notemigonus crysoleucas*)	Common
Brown bullhead (*Ictalurus nebulosus*)	Common
Rock bass (*Ambloplites rupestris*)	Rare
Pumpkinseed (*Lepomis gibbosus*)	Very abundant
Largemouth bass (*Micropterus salmoides*)	Common
Yellow perch (*Perca flavescens*)	Very abundant
Pikeperch (*Stizostedian vitreum*)	Rare
Amphibians	
Two-lined salamander (*Eurycea bislineata*)	Common
Purple salamander (*Gyrinophilus porphyriticus*)	Common
American toad (*Bufo americana*)	Common
Leopard frog (*Rana pipiens*)	Common
Green frog (*Rana clamitans*)	Very abundant
Bullfrog (*Rana catesbiana*)	Common
Reptiles	
Snapping turtle (*Chelydra serpentina*)	Common
Painted turtle (*Chrysemys marginata*)	Abundant
Water snake (*Natrix sipedon*)	Rare
Aquatic birds	
Pied-billed grebe (*Podilymbus podiceps*)	Rare (summer)
Great blue heron (*Ardea herodias*)	Common (summer)
Eastern green heron (*Butorides virescens*)	Common (summer)
Canada goose (*Branta canadensis*)	Common (transient)
Common mallard (*Anas platyrhynchos*)	Common (summer)
Common black duck (*Anas rubripes*)	Rare (summer)
Blue-winged teal (*Anas discors*)	Rare (summer)
Wood duck (*Aix sponsa*)	Common (summer)
Bufflehead (*Bucephala albeola*)	Rare (transient)
Osprey (*Pandion carolinensis*)	Common (summer)
Herring gull (*Larus argentatus*)	Abundant (permanent)
Eastern belted kingfisher (*Megaceryle alcyon*)	Common (summer)
Eastern kingbird (*Tyrannus tyrannus*)	Rare (summer)
Mammals	
Raccoon (*Procyon lotor*)	..
Red fox (*Vulpes fulva*)	..
Chipmunk (*Tamias striatus*)	Common
Beaver (*Castor canadensis*)	..
Muskrat (*Ondatra zibethicus*)	Abundant
Norway rat (*Rattus norvegicus*)	Rare-common
Cottontail (*Sylvilagus floridanus*)	Abundant
Deer (*Odocoileus virginianus*)	Common

ticularly in winter. In the autumn of 1951, hundreds of dead perch, all about 5½ inches long, were washed on the shore of the reservoir, but the cause of the mortality was not determined. Ice fishing produced the heaviest fishing pressure on yellow perch.

The largemouth bass population in the reservoir at the time of study supported an active summertime sport fishery. Examination of stomach contents indicated a change in diet as the fish grew from juveniles to adults. Bass less than 4 inches long were insectivorous with damselfly nymphs making up the greatest part of the diet. Larger bass had fed on crayfish and small fish. During the spawning period in June, about 50 bass nests were concentrated in a 30,000-square-foot part of the bay. Thus, each male guarded a territory on the order of 600 square feet. This is more compact and crowded than the 1,200 to 2,700 square feet of typical bass nesting territories as described by Eddy and Surber (1947). Other nests were observed elsewhere in the bay, indicating intensive use of the area by bass. Favorable water depths and temperatures, and the vegetation present, undoubtedly contributed to the reproductive success of the bass there.

Pumpkinseeds were the most abundant fish in the reservoir. They comprised the largest proportion of samples taken by seine, fyke net, or rod and reel. Pumpkinseeds made their nests and spawned in the shallow waters adjacent to the bass spawning area. Their diets were quite varied but mostly consisted of clams and occasionally *Tendipes* larvae. In a few specimens the sole item in the stomach was aquatic plant material, perhaps accidentally ingested with other food items. The pumpkinseeds were heavily infested with strigeid metacercariae (apparently *Neascus vancleavei*). The ectoparasites were embedded in the soft tissues around the mouth, opercula, fins, and caudal peduncle. A few were in the lateral surface tissues.

Rock bass abundance in the reservoir was low. They fed in the bay area but apparently nested elsewhere since no nests were seen. Their principal foods were crayfish and small fish. Unlike the pumpkinseeds, rock bass were not infested with strigeids.

Information on growth was obtained from scale samples taken from the fish collected. Plastic impressions of the scales were examined in an Eberbach-type projector and measured for back calculation. The data for four species are plotted in Figure 6. They suggest the fish in Jamesville Reservoir were stunted as compared with the same species in other areas (Connecticut Board of Fisheries and Game, 1941; Beckman, 1946).

Amphibians Leopard frogs bred actively in the extreme southern end of the bay in early April. After mating, the frogs dispersed and the area was used by large numbers of American toads and a few bullfrogs. At one time, more than 200 toads were seen mating in an area approximately 30 feet in diameter. After the breeding season very few toads were seen in the vicinity of the bay. The food of the toads and bullfrogs collected was almost exclusively terrestrial

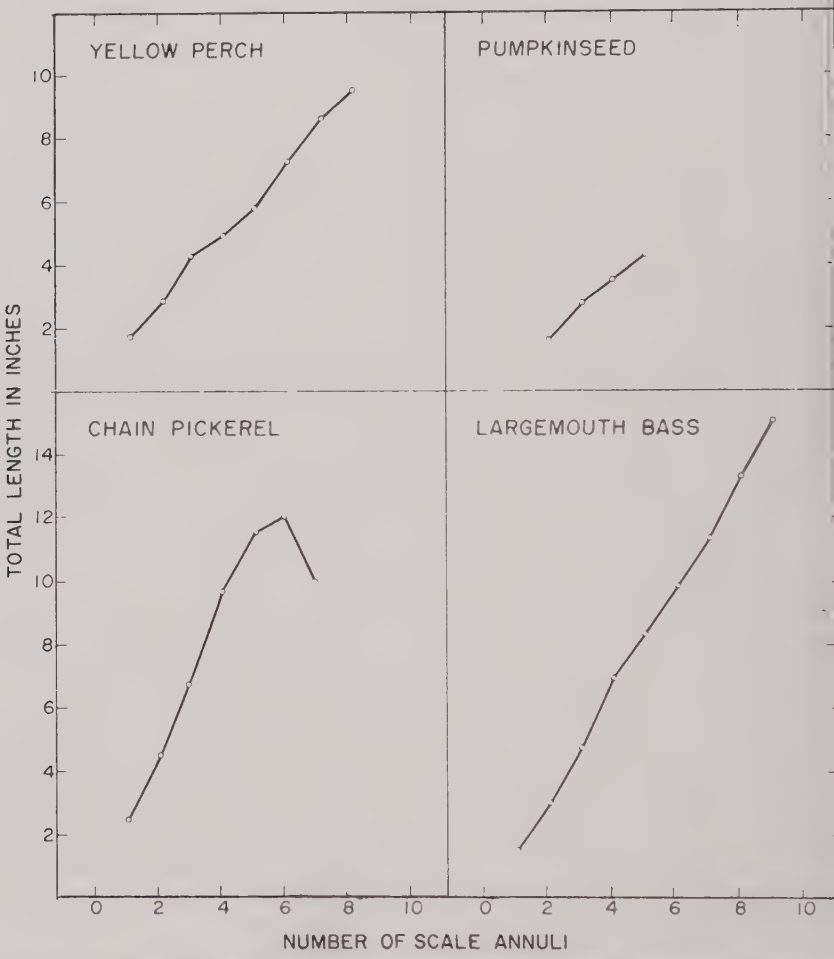

Figure 6. Length in relation to age for four species of fish collected in Jamesvill Reservoir.

invertebrates, i.e., beetles, butterfly and moth larvae, millipedes, an spiders. Crayfish remains were found in one bullfrog stomach.

Green frogs were the most abundant amphibian and were see throughout the bay from early spring to autumn. They fed entirel on terrestrial insects, particularly beetles.

Reptiles Snapping turtles were common in the area and som grew to large size. The largest specimen collected was a 30-poun male. Seven were collected, four of which had food in their stomach Most of the stomachs were packed with aquatic vegetation, particular *Spirogyra* and the leaves and stems of waterweed. Three of the fou stomachs contained animal remains, including fragments of a cra

fish, scales and bones of what appeared to have been a 4-year-old centrarchid fish, and skin and feather fragments from an unidentifiable juvenile bird. The diet list is consistent with that reported by Alexander (1943) for snapping turtles in a swamp habitat. All the turtles were moderately to heavily parasitized with freshwater leeches (*Placobdella parasitica*) which were attached in the axillae of the limbs and to the neck.

BIRDS Twenty-three species of birds were observed in and around the area, 13 of which used the water area for a large part of their day-to-day living. Great blue herons, ospreys, and kingfishers were seen from time to time capturing fish in the shallow bay. Because of their relatively low abundance, however, these birds probably were not serious predators. Wood ducks and their young (at one time a flock of 20) were often seen in the water around Station C. This suggests the ducks nested in the area although no nests were found.

MAMMALS Only the muskrat actually lived in the study area, but other mammals visited it for food and water or, possibly, for refuge. Local residents reported trapping beavers in the area many years ago, but the last one was seen in the winter of 1951–52. Muskrats were trapped commercially in and around the thick stands of cattail. Examination of muskrat carcasses in March 1953 indicated the animals to be healthy and in good condition. Norway rats frequented the trash heaps near the commercial recreation area and one was seen near Station C. During late summer, when great areas of muddy bottom were exposed, raccoons invaded the area to dig for crayfish. No raccoons were actually seen but tracks and scats were clear evidence of their activities. Deer visited the area frequently for water and browse. Their tracks and other sign were seen at all times of the year and occasionally individuals were seen.

DISCUSSION

The animals observed in and around Jamesville Reservoir are quite typical of well populated rural areas. They are the kinds that "get along" with people. Thus, the noises and occasional intrusions of picknickers, boaters, or fishermen are not likely to cause them to permanently abandon the area. Of much greater influence are marked changes in water level.

During the period April 20 through December 15, 1952, the water level in the reservoir dropped a total of 52½ inches and then returned to the previous spring depths. As a result, 75 per cent of the study area was without standing water from September 17 through December 7. At the time of minimum depth (November 6), there was only 8 inches of water at Station A and none at Stations B and

C (although the soil was moist). Precipitation during the fall raised the level so that by December 15 it was about the same as it had been the previous April.

The lowered water level exposed thick beds of aquatic vegetation and, in the extreme southern end of the bay, large areas of soil. Ducks, muskrats, turtles, and fish were forced to migrate to the northern portion of the bay or into the main part of the reservoir. Most of the frogs moved also, although some remained in the few pools that were left. The invertebrates were most affected by the changing water level. Crayfish tunneled into the exposed mud flats, presumably to await the return of the water, and while they were so tunneled many were dug out by raccoons. The aquatic insects probably also moved into deeper water but many were trapped and died in the small pools that eventually dried. The vast expanse of exposed bottom represented an extensive feeding area lost to the ecosystem. Nevertheless, the food supply in the reservoir appeared to be adequate most of the year, but it is probable that additional pressure is exerted on the available supply by the consumers driven there from the shallow areas during periods of low water.

Several of the fish species are competitors for certain foods, particularly crayfish, *Tendipes* larvae, and damselfly nymphs. Thus, there would be increased predation on these organisms as the fish populations expanded in the main part of the reservoir. It seems reasonable to infer that the apparently stunted condition of the fish examined was due in large measure to periodic food shortages plus overpopulation of the fish. The perch mortality and the high density of largemouth bass nesting territories recorded suggest that an imbalance existed in the fish population.

Increased recreational use of the reservoir, especially by fishermen, may be expected since this is the national trend. Increased use would be desirable, if, for example, the fishermen were to help remove the excess crop of yellow perch and pumpkinseeds and thus make more food and space available to the species that generally are considered more desirable game fish. On the other hand, increased recreational use might also result in driving off a few wildlife species. The majority of the species present, however, have adjusted well to the presence of humans and probably would continue to use the area.

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THE DDT CONTENT OF SOME FISHES AND SURFACE WATERS OF NEW YORK STATE[1]

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ABSTRACT

Sixteen species of fish taken from New York waters contained from 0.2 to 7.0 ppm of DDT on a fresh-weight basis. Certain tissues such as visceral fat, gills, eggs and the sex organs contained up to 40 ppm. The surrounding water and sedimentary mud contained much smaller amounts, indicating that fish may concentrate DDT in their tissues. Aldrin, dieldrin, lindane, chlordane, heptachlor and endrin were not detected at a sensitivity limit of 0.03 ppm.

Conservationists have become concerned about the possibilities of pesticide poisoning of fish and other aquatic wildlife in New York State waters (New York State Joint Legislative Committee on Natural Resources, 1963). Direct application of pesticides to surface waters for mosquito and blackfly control is only one source of contamination. Pesticides may also enter surface waters by runoff from treated agricultural or forest lands.

Previous workers have reported the presence of DDT and its metabolites in fish and other animals (Allison *et al.*, 1963; Finley and Pillmore, 1963). The present investigation is a preliminary survey of the chlorinated pesticides found in representative fish taken from New York lakes and streams. Gas chromatographic detection methods (Gutenmann and Lisk, 1963) have been employed because they reveal both the identity and the concentration of most chlorinated pesticides at nanogram levels in the sample extracts. DDT and its decomposition products were the only pesticidal residues found. Aldrin, dieldrin, lindane, chlordane, heptachlor, and endrin all give more sensitive responses than does DDT (Goodwin *et al.*, 1961), so that less than 0.03 ppm of these pesticides in all samples can be reported.

[1] Approved by the Director of the New York State Agricultural Experiment Station at Geneva for publication as Journal Paper No. 1378, January 20, 1964. The authors thank Dean Charles E. Palm and Director D. W. Barton at whose suggestion these studies of the effects of pesticides on fish were initiated. We also wish to thank Donald Collins and Hugo Jamnback of the New York State Biological Survey and E. F. Taschenberg of the New York Experiment Station at Fredonia who supplied several of the samples.

Table 1. Experimental Procedure

Item	Procedure I	Procedure II
	Operation	
Extraction	Acetone	Skellysolve B — 80% v/v Ethanol — 20% v/v
Partition	Hexane-aqueous sodium sulfate solution	Saturated sodium chloride solution
Cleanup	None	a. Fluorosil column* b. Acetonitrile partition for high-fat samples §
	Chromatographic condition	
Column substrate	5% silicone grease	5% silcone grease
Column support	Chromosorb W, 60–80 mesh	Chromosorb W, 60–80 mesh
Column length, shape	2 feet, U-shaped	3 feet, coiled helix
Column diameter, inside	¼-inch glass	⅛-inch glass
Nitrogen flow rate	60 ml. per minute	40 ml. per minute
Operating temperatures	200° C. column 265° C. flash heater 230° C. detector	200° C. column 200° C. injection port 200° C. detector
Detector	$Radium_{226}$ Electron affinity	Tritium H_3 Electron affinity

* After Johnson (1963).
§ After Jones and Riddick (1952).

Two sample processing procedures were used, both of which have been described previously (Bann, 1962; Gutenmann and Lisk, 1963). Procedure I gave DDE as the principal metabolite of DDT in the fish, with a retention time of about 3.5 minutes relative to aldrin at 1.8 minutes. Peaks for DDT and DDD were insignificant in most cases, because the fish were blended whole, giving the enzymes present in the liver and other tissues time to degrade the DDT before extraction. Standard DDE yielded a single peak, while standard DDT showed about 5 per cent thermal conversion to DDE when chromatographed using the operating conditions stated (Table 1).

In Procedure II the separate tissues were dissected and immersed in ethanol before blending to inhibit enzyme action. Three peaks representing DDE, *o,p'*DDT, and *p,p'*DDT were obtained with retention times of 6.1, 8.7, and 11.2 minutes, respectively, relative to aldrin

Table 2. Residues of DDT in Samples of Fish and Their Aquatic Environment in New York in 1963

No.	Sample	Source and location	Date	Description			Amount found expressed as total DDT in ppm *	Procedure §
				Length (inches)	Weight (pounds)	Part sampled		
1	Water	Lake George (Bolton)	September	xxx	xxx	xxx	0.000015	IIa
2	Water	Hudson River (Corinth)	"	xxx	xxx	xxx	0.00005	IIa
3	Water	Seneca Lake (Geneva)	"	xxx	xxx	xxx	0.00011	IIa
4	Water	Stony Kill (Hurley)	"	xxx	xxx	xxx	0.00033	IIa
5	Mud	Cayuga Lake (Taughannock)	October	(composite of three samples from 80–100 feet offshore)			0.07	I
6	Mud	Cayuga Lake (Ithaca)	"	(from lower inlet at lake)			0.06	I
7	Algae and moss	Stony Kill (Hurley)	September	(from stagnant pond near site of No. 4)			0.01	II
8	Sunfish	Cayuga Lake (Taughannock)	October	..	..	whole	0.2	I
9	Bluegill	Cornell Hatchery (Ithaca)	November	..	..	whole	0.2	I
10	Carp	Cayuga Inlet (Ithaca)	October	..	..	whole	0.2	I
11	Rainbow trout	Cayuga Lake (Esty's Point)	November	12	0.7	whole	0.2	I
12	"	Lake Harkness (Newcomb)	July	10	0.4	edible flesh	0.9	II
12a	"	"	"	10	0.4	gills	4.4	II
13	"	Cayuga Lake (Esty's Point)	November	10	0.3	whole	0.9	I
14	"	"	"	14	1.1	testes	0.02	I
15	"	"	"	22	4.8	eggs	1.4	I
16	Rock bass	Cayuga Lake (Taughannock)	October	..	..	whole	0.3	I
17	Smelt	Fall Creek (Ithaca)	April	..	..	whole	0.4	I
18	White sucker	Cayuga Lake (Taughannock)	October	..	..	whole	0.5	I
19	Alewife	"	"	..	..	whole	0.7	I
20	"	Cornell Hatchery (Ithaca)	November	..	..	whole	0.8	I
21	"	Cayuga Lake (Esty's Point)	"	(from stomach of No. 15)			1.0	I
22	Smallmouth bass	Cayuga Lake (Taughannock)	October	..	..	whole	0.7	I
23	Largemouth bass	Lake George (Bolton)	June	10	0.4	composite	0.9	II
23a	"	"	"	10	0.4	edible flesh	0.2	II
23b	"	"	"	10	0.4	gills	4.3	II
23c	"	"	"	10	0.4	visceral fat	18.4	II
23d	"	"	"	10	0.4	testes	38.4	II

24	Pike	Lake Erie (Silver Creek)	November	14	0.8	edible flesh	0.2	II
24a	"	"	"	14	0.8	testes	3.7	II
25	"	"	"	13	0.7	visceral fat	4.2	II
26	Yellow perch	Cornell Hatchery (Ithaca)	"	(immature)		whole	0.3	I
27	"	Cayuga Lake (Taughannock)	October	..	..	whole	1.1	I
28	"	Lake Erie (Silver Creek)	November	10	0.5	edible flesh	0.3	II
29	"	"	"	10	0.5	eggs	2.4	II
30	"	"	"	11	0.5	testes	11.5	II
31	"	"	"	10	0.5	visceral fat	12.5	II
32	Brook trout	Panther Lake (Old Forge)	"	..	..	whole	0.1	I
33	"	East Lake (Old Forge)	"	..	..	whole	0.6	I
34	"	Honnedaga Lake (Forestport)	"	..	..	whole	0.1	I
35	"	Upper Preston Pond (Newcomb)	July	6	0.2	edible flesh	1.5	II
36	Lamprey	Cayuga Lake (Taughannock)	October	..	..	whole	5.3	I
37	Channel catfish	"	November	..	..	whole	3.8	I
38	Lake trout	Seneca Lake (Geneva)	September	..	1.3	edible flesh	1.2	II
39	"	Cayuga Lake (Taughannock)	October	(immature)		whole	3.6	I
40	"	"	"	(mature male)		whole	6.2	I
41	"	"	"	(5-year-old female)		less viscera	7.1	I
41a	"	"	"	eggs from No. 41			2.8	I
42	"	"	"	composite of Nos. 40 and 41		visceral fat	29.0	I
43	"	Seneca Lake (Clark's Point)	"	..	14.0	spleen	3.0	II
43a	"	"	"	..	14.0	gills	3.7	II
44	"	Lake Clear (Tahawus)	June	..	..	eggs	3.5	II
45	"	Seneca Lake (Plum Point)	October	..	6.0	eggs	2.3	II
46	"	"	"	..	1.0	eggs	3.5	II
47	"	"	"	..	4.5	eggs	3.6	II
48	"	"	"	..	1.0	eggs	4.1	II
49	"	"	"	..	6.0	eggs	4.6	II
50	"	"	"	..	1.5	eggs	4.6	II
51	"	"	"	..	1.5	eggs	5.0	II
52	"	"	"	..	8.0	eggs (immature)	6.9	II

* For pure water at 25° C. the solubility limit of DDT is 0.0012 ppm.
§ See Table 1.

at 3.1 minutes. Standard solutions of each of the three materials gave single peaks with no thermal conversion. The middle peak, much smaller than the other two, also represents *p,p'*DDD (Allison *et al.*, 1963; Finley and Pillmore, 1963). For the present purpose the three peak areas were measured separately, converted to nanograms of each material, then added together and expressed as total DDT.[2]

The extraordinarily low solubility of DDT in water (Bowman *et al.*, 1960) made a supplementary concentration process necessary. Procedure IIa consisted in pumping several hundred gallons of water through the standard carbon filter described by the American Water Works Association (1962). The carbon was air-dried and extracted for 72 hours in a Soxhlet apparatus with a mixture of 3 parts chloroform and 1 part methanol by volume. The methanol was removed by shaking with water. The extract was dried and concentrated according to Procedure II, during which most of the chloroform was replaced with Skellysolve B. No cleanup was necessary.

Holden (1962) has shown that DDT in excess of the solubility limit soon settles out of suspension. Therefore, it is not surprising that Cayuga Lake bottom mud contained 50 times more DDT than can be dissolved in the same weight of water. In contrast to algae and other aquatic plants which absorbed limited amounts of DDT from water (Sample No. 7, Table 2), fish were able to accumulate much larger amounts of the pesticide because of the efficient pumping and filtering action of their gills, and the convenient storage reservoir in their fatty tissues.

Table 2 contains analyses of 16 species of fish taken from New York waters, arranged approximately in order of increasing DDT content as follows: sunfish or pumpkinseed (*Lepomis gibbosus*); bluegill (*Lepomis macrochirus*); rainbow trout (*Salmo gairdneri*); rock bass (*Amblopites rupestris*); smelt (*Osmerus mordax*); white sucker (*Catostomus commersoni*); alewife (*Alosa pseudoharengus*); smallmouth bass (*Micropterus dolomieui*); largemouth bass (*Micropterus salmoides*); pike (*Esox lucius*); yellow perch (*Perca flavescens*); brook trout (*Salvelinus fontinalis*); lake trout (*Salvelinus namaycush*); lamprey (*Petromyzon marinus*); channel catfish (*Ictalurus punctatus*).

The DDT content of the whole fish ranged from 0.2 ppm to 7 ppm on a fresh-weight basis. The edible flesh would be somewhat lower in DDT than the fish as a whole, because certain tissues like gills, visceral fat, eggs and the sex organs contain up to 40 ppm. While these residues fell short of the enormous concentration of DDD from 0.02 ppm in the water of Clear Lake (Calif.) to 2,700 ppm in the fat of black crappie from this lake (Hunt and Bischoff, 1960); they were

[2] Detailed data are available upon request to the senior author.

in line with the concentration of 1 to 7 ppm of DDT found in cutthroat trout exposed to the pesticide in food or water for 18 months (Allison *et al.*, 1963).

None of these fish showed symptoms of acute DDT poisoning. Whether sufficient DDT may accumulate in the eggs to interfere with reproduction requires further investigation.

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GENERAL NOTES

COMPATIBILITY OF DEER AND GROUSE

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On November 18, 1963, during the first half hour of the big game season in western New York, the writer made an unusual observation of interspecies behavior of white-tailed deer (*Odocoileus virginianus*) and ruffed grouse (*Bonasa umbellus*). The incident occurred on the property of Howard M. Woods in the town of South Bristol in Ontario County (N. Y.).

Shortly after 7 a.m. a doe accompanied by a fawn emerged from a mature stand of hardwood timber into a growth of sapling and pole-stage aspens interspersed with open grassy areas. Both deer grazed uninterruptedly until the fawn discovered a ruffed grouse. The next 15 minutes were devoted to a playful contest involving both the grouse and the fawn. The fawn would make repeated advances at the grouse, each time approaching the bird slowly and, when nearly upon it, jumping forward much as a cat would pounce upon a mouse. Not until the deer was nearly upon it would the grouse withdraw either by running to the side or by flying a short distance in a semicircle and alighting each time only a few feet from the fawn. On one occasion the fawn approached the bird with its head lowered and appeared to nudge the grouse into the air with its nose. Prior to each advance, gestures of defiance and challenge were demonstrated by both the deer and the grouse. The fawn would paw the ground and bob its head while the grouse would ruffle its feathers and strut back and forth in front of the deer. Finally the grouse, apparently having had enough, took wing and disappeared through the hardwoods. The doe showed little interest in this "sparring" and continued to graze completely undisturbed by the whole affair.

NOTES ON THE NEW ENGLAND COTTONTAIL IN EASTERN NEW YORK[1]

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In the upper Hudson Valley of New York, the eastern cottontail (*Sylvilagus floridanus*) did not originally occur (cf. Nelson, 1909; Stone and Cram, 1902). The New England cottontail (*S. transitionalis*) and the snowshoe hare (*Lepus americanus*) were the only native leporids. More recently, the European hare (*Lepus europaeus*) has entered the area by importation, and the eastern cottontail has become established probably both by importation of western stock and by spread of native rabbits from the south and west. Thus, there are now two species of cottontail and two species of hare in at least general sympatry over parts of eastern New York.

Identification of the two species of cottontail is virtually impossible in the field, and is difficult even in the hand. Typically, *S. transitionalis* has a black spot between the ears and a somewhat darker pelage, but occasional individuals do not conform to this pattern. For a full discussion of species characteristics, see Fay and Chandler (1955).

This paper is mainly concerned with the geographical and ecological distribution of the New England cottontail in Rensselaer County. Although this species is found over much of the Northeast and would appear to be a potentially important

[1] The authors wish to acknowledge aid and encouragement from Joseph Dell and Donald Schierbaum of the New York State Conservation Department. Philip Alkon of that Department also made valuable suggestions. Part of the work was done by the junior author as a graduate research project at the State University of New York at Albany.

Figure 1. Map of Rensselaer County (N. Y.) showing 1000-foot contour and localities where the two species of cottontail were taken. Numeral below each locality indicates number of specimens taken there.

game animal, relatively few studies of its life history and management have been made. Compared with that of the common cottontail, its life is very poorly understood. The excellent reports of Dalke (1942) for Connecticut and of Fay and Chandler (1955) for Massachusetts have not been paralleled in New York. This brief note does not fill the gap, but it may stimulate further interest in this species.

From 1953 to 1961, 52 cottontails were collected in Rensselaer County. All parts of the county were sampled by hunting, live trapping and collecting road kills. Of these specimens, 42 proved to be the eastern cottontail and 10 were the New England cottontail. Their distribution is shown in Figure 1. Also, eight skulls were submitted by hunters who were contacted through local game clubs.

Judging from these records, the two species appear to be geographically as well

as ecologically separated in Rensselaer County, in contrast to the findings of Fay and Chandler (1955) in Massachusetts. This may be due to the topography of the country, with the Rensselaer plateau rising in the east-central portion to over 1,800 feet. The wooded top of this plateau offers suitable habitat for the New England cottontail, while the cultivated lower areas are occupied by the eastern cottontail. The New England cottontail also occurs in the Taconic range adjacent to the eastern margin of the county as well as in the Berkshires of Massachusetts and Connecticut (Goodwin, 1935; Fay and Chandler, 1955). It no doubt occurs in similar habitat along the extreme edge of New York State.

The eastern cottontail has a much wider ecological distribution in Rensselaer County than does the New England cottontail. Within the altitudinal range of 25 to 1,000 feet, it occurred in open and cultivated land, brushy fields and second-growth forest, but never far from open land. Probably this single factor is most important in its distribution. The specimens of the New England cottontail collected were all from wooded land at elevations in excess of 1,000 feet. On the Rensselaer plateau, the native forest is largely a secondgrowth hemlock-hardwood mixture. Swampy areas with natural stands of spruce are scattered over the higher levels of the plateau, and extensive areas have been reforested with conifers. New England cottontails were collected from all of these habitats. On the basis of the small number taken, it was not possible to determine any preference for hardwoods vs. conifers, brushy growth vs. mature forest, etc.

Although distribution maps of various authors show the New England cottontail as occurring over practically all of eastern New York, it has in fact been replaced over much of that area by the eastern cottontail. Considering the preferred habitats of the two species, it is probable that this was brought about by changes in habitat rather than by direct competition between the species. In this we agree with Fay and Chandler (1955) who pointed out that the two species show such distinct differences in habitat selection that competition should not be significant. It is possible, however, that the New England cottontail would exist in the more open areas if the other species were not there.

As a game species, the New England cottontail appears to be little exploited. Fay and Chandler (1955) reported that, in areas where both species were present, less than 25 per cent of the cottontails taken were this species. Three factors may contribute to this: (1) it may be less common than the eastern cottontail, although few population studies have been made; (2) its habitat is somewhat more remote and more difficult to traverse than the more open areas preferred by the eastern cottontail; (3) it seems to be less active in daylight hours than the eastern cottontail, preferring the hours of twilight.

In eastern New York, as in much of the Northeast, there has been a steady increase in forested land as a result of abandonment of submarginal farms. At present, conditions on many of these farms are still brushy enough to favor the eastern cottontail. But, as succession continues, the New England cottontail may reclaim some of its former range. It has been shown to be practical to manage forested lands so as to increase populations of the eastern cottontail (McDonough, 1960). Whether this is necessary or desirable in New York and whether the New England cottontail can become as popular and suitable a game species as the other are problems for further study.

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AN UNDERWATER SLED

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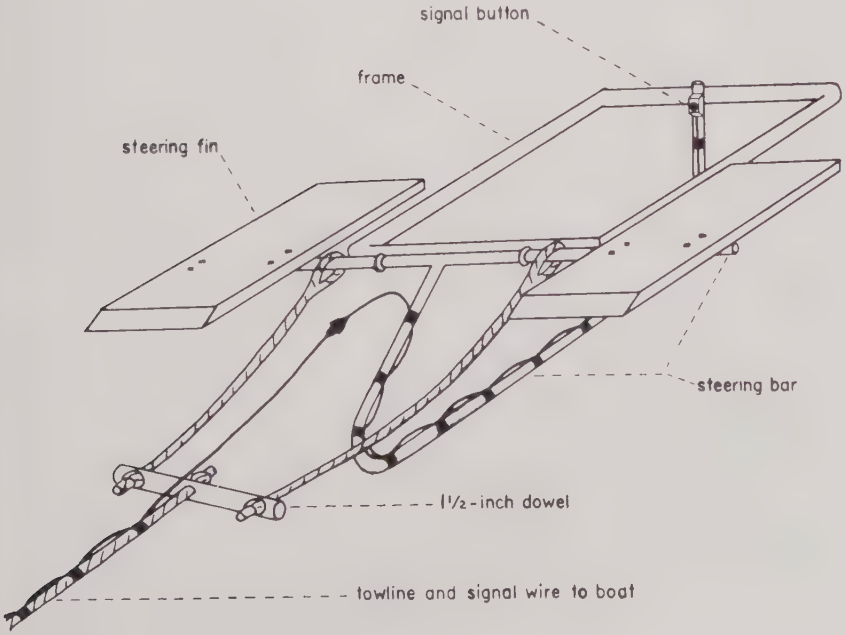
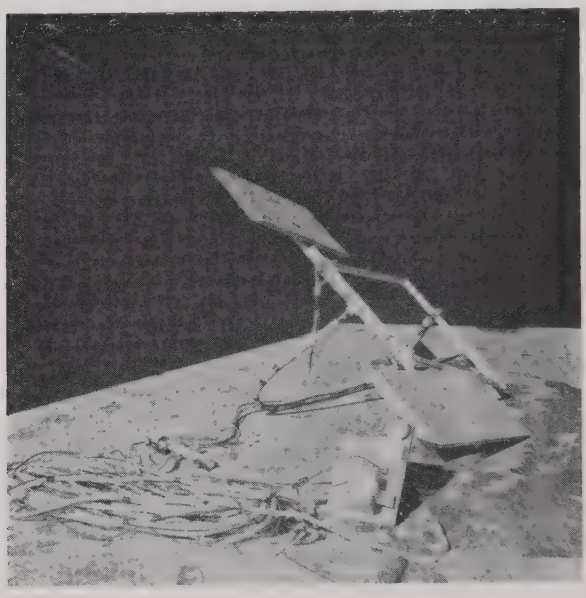
When using self-contained underwater breathing apparatus in the course of fisheries investigations on large bodies of water, there is often a need for easier and more rapid means of underwater travel than the use of swimming fins (foot-fins) alone. Various commercially made vehicles are available, but they are quite expensive. For this reason the author devised the sled pictured. It is easily and cheaply built, can be pulled by any outboard motor rated over 5 horsepower, and provides an efficient vehicle for underwater travel. Materials used were as follows:

Frame:	1-inch aluminum tubing
Steering bar:	½-inch galvanized pipe
Steering fins:	¾-inch hardwood
Towline:	½-inch manila line
Wiring:	#14 insulated house wire
Signal bell:	6-volt doorbell, bell-button and 6-volt battery

The steering bar was bent at the angle shown to provide enough leverage for easy control and to provide a skid to hold the diver and sled off the bottom. The horizontal part of the steering bar is held snugly to the frame with eye-bolts. The fins are held in position with U-bolts. The bell and battery were mounted on a board which had clamps attached to hold it in place next to the boat operator. A set of "dot-dash" signals for "stop, start, slower, faster, left, right, etc." were painted both on the board and on the fins of the sled. The signal wire from the boat to the sled was taped to the towline, with connections provided at both ends. In general, 100 feet of towline is needed for every 60 feet of depth attained.





In practice, with the bell and battery mounted on the boat and the towline attached, the diver hooks one elbow over the sled frame and grasps the steering bar with his free hand. The bell-button, mounted on the steering bar where it is easily operated, provides a means of constant contact between the diver and the boat operator, and the diver's signals permit him to direct the movements of the boat. By prearrangement, a sharp tug on the towline by the boat operator constitutes a check on the diver's condition, to which the diver responds via the bell. A second diver should be in the boat, fully dressed for diving, at all times. If it is intended to use this type of sled at depths exceeding 60 feet, a second diver should be on the sled; a diver in the boat could not reach a diver in trouble fast enough at depths greater than 60 feet.

Use of such a sled is NOT recommended for an inexperienced diver, for many reasons. Panic comes easily enough to an inexperienced diver when diving only for pleasure. Attempting to control a sled and make observations of habitat or fish populations at the same time takes training. Should any of the some two dozen necessary safety rules (Conference for National Cooperation in Aquatics, 1962) be ignored the results could be fatal. Ascents and descents especially must be carefully controlled to prevent serious damage to the inner ear or respiratory tract. Used cautiously by an experienced diver, however, this sled can multiply many times the distance he can cover on one tank of air, and it will permit him to do so with a minimum of effort.

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JAW MARKING TROUT WITH INJECTED DYES[1]

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Ten water-soluble dyes were injected into the lower jaws of yearling brown trout (*Salmo trutta*) and brook trout (*Salvelinus fontinalis*) in an attempt to produce long-term, easily applied, nontoxic, non-mutilating marks. The resulting marks were partially successful, as shown in Table 1, in that two dyes, Pontamine

Table 1. Results of Jaw Marking Yearling Trout with Injected Dyes at a Temperature of 47° F.

Name of dye *	Number marked	Species		Dye-color	Dye concentration §	Duration of mark †
		Brown trout	Brook trout			
Alizarine Cyanone Green	10	x		green	50	9 days
Superchrome Black TS (Conc)	9	x	x	black	71	under 1 month
Lanamide Scarlet G	11	x	x	red	50	under 1 month
Solantine Yellow RL ‡	10	x		yellow	33	2 months
Milling Scarlet	10	x		red	25	3 months
Induline B Extra	10	x	x	violet	50	3–4 months
Alizarine Blue 2RC	13	x		blue	42	4 months
Solantine Red 8 BLN	10	x	x	red	50	4 months
Pontamine Fast Pink BL	21	x		red	85	over 9 months
Pontamine Fast Pink BL	19	x		red	75	over 9 months
Solantine Turquoise G	10	x	x	blue-green	100	over 9 months

* Pontamine Fast Pink BL obtained from E. I. DuPont De Nemours & Co.; all others from Allied Chemical Corp.
§ In milligrams of dye per milliliter of water.
† For Pontamine Fast Pink BL and Solantine Turquoise G, more than 75 per cent of the fish retained the mark for the full period; for the other dyes the proportion was less than 50 per cent.
‡ This dye might be more effective against a dark background.

Fast Pink BL and Solantine Turquoise G, lasted visibly for over 9 months. Although this length of time is sufficient for certain studies (the time would probably be less at higher temperatures) dyes which produce marks lasting for 1 to several years are undoubtedly available.

Lower-jaw marks are advantageous because the head of the fish is not usually eaten, and also because only 1 to 5 drops of dye (in the amounts used, none of the dyes produced visible deleterious effects) are needed to produce a mark on the invariably light colored background. The resulting mark is a thin line under the skin, paralleling the bones of the lower jaw. A separate color can be used for each lower jaw.

The mark is produced by inserting a No. 26 hypodermic needle at the tip of the jaw or dentary bone and running it under the skin along the entire length of the jaw to the articular bone. As the needle is quickly withdrawn a gentle pressure

[1] A contribution of Federal Aid in Fish and Wildlife Restoration Project F-9-R.

on the plunger leaves a line of dye in the channel created. Many trout can be marked with one small syringe of a saturated solution of dye, and, if only one color is desired on one side of the lower jaw, the method is faster than fin clipping.

Solantine Turquoise G was used to jaw mark 400 two-year-old trout for a study of angling returns. A complete creel census accounted for almost every fish but it is interesting that the mark was not noticed by any angler.

The formula $C = (X + 1)^n - 1$ can be used to determine the number of different marks possible for any given number of separate colors and marking sites.[2] In this formula C equals the number of possible combinations, X the number of colors and n the number of sites to be used. As an example, using two colors and both lower jaws would provide eight combinations. An additional color would provide 15 combinations. Two colors and three sites would provide 26 combinations, and three colors and three sites would provide 63 combinations. Additional sites provide for more combinations than do new colors.

Some other work, although limited, was done with Pontamine Fast Pink BL. Large carp, for example, were injected in the cheek, body cavity and caudal peduncle with saturated solutions of the dye. From all three sites of injection, the fish often became entirely pink for a few days or weeks. Local pink marks in the cheek, belly or peduncle could still be distinguished after 14 months in about half of the injected fish. These tests were run at a constant temperature of 65° F. It is interesting that the boiled vertebrae of recently injected carp were dyed pink in the areas of growth.

It is apparent that individual fish of a species react differently to dyes with respect to both retention of color and toxicity and that this is true of different species also. Brook trout appear to retain the local mark caused by Pontamine Fast Pink BL for a longer period than do brown trout. Temperature is also a probable factor affecting retention of marks.

[2] This formula was furnished by John Deagle of Rensselaer Polytechnic Institute, personal communication.

SOME NOTES CONCERNING THE TOXICITY OF ANTIMYCIN A TO CARP AND OTHER FISH[1]

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Antimycin A is an antibiotic that has been extensively tested by the Federal Fish Control Laboratory at LaCrosse, Wisconsin, in cooperation with the Wisconsin Alumni Research Foundation and S. B. Penick and Company. Tests in aquaria and small ponds have shown it to be a general fish poison that produces rapid kills at concentrations of a few parts per billion but that becomes nontoxic in a few days. The compound is a relatively insoluble white powder with long shelf-storage life.

At the Fish Laboratory at Livingston Manor (N. Y.), Antimycin A was tested in an unsuccessful attempt to develop a poison bait for the selective control of carp (*Cyprinus carpio*). In addition, one limited but successful test (carried out in cooperation with the foregoing organizations) with the compound used as a contact poison was made in a quarter-acre pond.

Antimycin A was lethal to large carp when force-fed in pure form at doses of less than 1 milligram of chemical per kilogram of body weight over a period of 1 to 2 days at a temperature of 65° F.[2] The compound was palatable to laboratory carp when fed at a 1 per cent level in 200-milligram baits composed of equal amounts of flour and fish pellet meal. Doses of 3 milligrams per kilogram of body weight were consistently lethal at 65° F. to carp over a period of 1 to 4 days after ingestion of bait. Occasional fish survived at lower doses. In two tests performed in quarter-acre ponds at temperatures of 63° to 64° F., approximately a quarter of the 100 carp used in each test were killed by baits most of which were not eaten. Dissection showed that unaffected fish had not eaten, and further tests in aquaria and ponds

[1] A contribution of Federal Aid in Fish and Wildlife Restoration Project F-9-R.
[2] Derse and Strong (1963) reported that rats survived 12 milligrams per kilogram administered by stomach tube.

indicated that it might be impossible to develop even a placebo bait that would be acceptable to a majority of the individuals in a carp population.

The baits used in one of the pond tests contained 17 grams of Antimycin A, enough if completely dissolved to provide a concentration of 20–25 parts per billion in the pond. Since carp held in live cages were not affected over a period of days, it follows that little of the compound dissolved from the baits. Negligible solubility was further confirmed by assays of baits soaked for 24 hours which indicated that none had been lost. Some dissolving action does take place, however, as shown by the fact that caged trout (*Salmo trutta*), sunfish (*Lepomis gibbosus*) and shiners (*Notemigonus crysoleucas*) were killed in 2 days in 350-gallon tanks by the Antimycin A in soaking but unavailable baits.

Formulations of Antimycin A are lethal when dispersed in water.[3] An emulsion containing 1.9 grams killed all carp, perch (*Perca flavescens*) and unidentified minnows in a quarter-acre pond. The formulation (by S. B. Penick & Co.) consisted of Antimycin A, 3 per cent; acetone, 10 per cent; methylated napthalene (Panasol AN2, a product of the American Oil Co.), 82 per cent; and an emulsifier (an anionic and nonionic blend composed of alkyl aryl sulfonate blended with polyoxyethelene sorbitan esters of mixed fatty and resin acids), 5 per cent. The pond, with dimensions of 290 x 38 x 2 feet, contained approximately 22,000 cubic feet of water. A large amount of aquatic vegetation and grass covered with filamentous algae blanketed most of the muddy bottom. The water had an M.O. alkalinity of 53 parts per million and a pH of 7.3. Heavy turbidity was made extreme by walking a grid pattern while applying the toxicant. Water temperature, which was 62° F. at the start of the test, gradually fell to 51° F. at the conclusion 4 days later. Inflow and outflow were 6,600 cubic feet per day during the experiment. In applying the toxin, 1.7 grams of Antimycin A were dispersed over the surface of the pond and 0.2 gram was dripped into the inlet for 8 hours, providing concentrations of 2.7 parts per billion and 3 parts per billion, respectively, in pond and inlet water.

At the beginning of the experiment the pond contained more than 100 unmarked carp ranging from 2 to 8 pounds in weight. To these were added 25 marked carp. None of these fish was visible at the beginning of the test.

Dozens of carp fry were sick at the surface 2 hours after initial application and all were dead in 6 hours. A dozen minnows were sick in 2 hours and dead in 9 hours. Six yellow perch were sick in 5 hours and dead in 9 hours. The large carp were affected over a longer period of time. Two hours after application of the poison 12 carp were sick at the surface. At 9 hours dozens were sick at and below the surface, but many were alert and avoided attempts at capture. At 14 hours many were dead. At 26 hours 88 large carp including 15 marked fish were removed. No living carp were seen at this time. At 96 hours the pond was drained and additional carp were removed from the mud and vegetation for a total of 116 unmarked fish and 25 marked. No living carp, minnows or perch were seen.

In order to provide information concerning detoxification of Antimycin A, seven marked carp were introduced into the pond 24 hours after the start of the experiment. All were recovered when the pond was drained 3 days later. One was dead and the others were slightly sick. One of the sick carp was yellow and probably would have died; death always followed the yellow stage, whether in ponds or aquaria. The others had normal coloration and would probably have lived. Survival of these late-planted fish would indicate that considerable Antimycin A had been lost because of deterioration and the influx of fresh water.

The few brown bullheads (*Ameiurus nebulosus*) and newts and the large number of frogs and crayfish present were not visibly affected by the poison.

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[3] Derse and Strong (1963) achieved a kill of goldfish at a concentration of 1 part per billion and also noted that concentrations of 1 part per billion and 100 parts per billion lost toxicity after 1 and 7 days, respectively.

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